REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE THIRD SESSION OF THE FORTY-SIXTH CONGRESS.

IN FOUR VOLUMES.

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PART 3.

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APPENDIX B B.

IMPROVEMENT OF HARBOR AT DULUTH, MINNESOTA, AND OF THE ENTRANCE TO SUPURIOR BAY, LAKE SUPERIOR—IMPROVEMENT OF THE HARBOR AT GRAND MARAIS, MINNESOTA.

REPORT OF CAPTAIN CHARLES J. ALLEN, CORPS OF ENGINEERS, BVT. MAJOR, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

(For letter of transmittal, see Appendix U.)

B B 1.

IMPROVEMENT OF HARBOR AT DULUTH, MINNESOTA.

The work at Duluth consisted in dredging in the inner harbor and in some repairs to piers bordering the canal, the latter done by day labor and purchase of materials in open market, the former by contract.

The dredging contract made August 21, 1878, having been re-extended to embrace the 25th of August, 1879, there were removed 23,197 cubic yards of material from the inner harbor between June 30, 1879, and that date, August 25, 1879.

Congress having, by act approved March 3, 1879, appropriated $25,000 for carrying on the improvement, advertisements were duly inserted inviting proposals for dredging in the inner harbor. The bids were opened on the 21st of August, and a contract entered into on the same day with Williams and Upham, they being the lowest bidders.

Dredging under this contract commenced on the 26th of August and was continued until the 22d of November, when the approach of winter forced the dredges off. The contract was extended to embrace the 25th of June, 1880. Work was renewed the 28th of April following and continued until the expiration of the extension. One hundred and thirty-seven thousand one hundred and ten cubic yards in all were removed by dredging during the fiscal year.

A complete survey of the harbor was made during the season, as part of the survey of Superior Bay ordered by section 2 of the river and harbor act approved March 3, 1879, to determine the best plan for harbor at the head of Lake Superior. The report, based upon this survey, is printed as Senate Ex. Doc. No. 153 Forty-sixth Congress, second session.

The harbor has generally, wherever dredging has been carried on, good depth of water, although many points require retouching, owing to the movable and shifting character of the bottom.

Large areas still remain to be dredged in order to carry out the existing project, viz, the deepening and enlarging of the basin bounded by Minnesota and Rice's Points and the submerged dike, the original estimate of cost of which was $269,739.25, not counting the cost of repairs to piers. There has been appropriated, or allotted, since the adoption of the present project, the sum of $176,049.20. Forty-one thousand eight hundred and sixty-nine dollars and nine cents of this amount have been expended in repairs to piers, &c. There remains to be appropriated for dredging the sum of $134,293.18. To economically continue this work, at least $50,000 should be annually appropriated in order to meet the wants of the rapidly increasing commerce of this important harbor. The piers bordering the canal stand much in need of timber renewal throughout their length above the water line, and not less than $15,000 should be appropriated for these repairs.

Congress by act approved June 14, 1880, appropriated for—

Improving harbor at Duluth, Minnesota: continuing the improvement, twenty-five thousand dollars.

With this appropriation, and the balance of funds on hand, it is proposed to continue the work of dredging the inner harbor and to make such repairs to piers as may be most necessary. At least $10,000 should be available at all times, with which to meet the effects upon the piers of severe storms.

This work is in the collection district of Duluth. Duluth, Minn., is the nearest port of entry.

The collections at this port for the fiscal year ending June 30, 1880, were $4,964.51.

Abstract of appropriations made for the harbor of Duluth, Minn., how expended, &c.

Appropriation.	Construction of breakwater.	Repairs of piers, &c.	Dredging inside harbor, &c.	Unexpended July 1, 1880.	Total.
By act approved March 3, 1871	$60,000 00				$60,000 00
By act approved June 10, 1872	50,000 00				50,000 00
Allotted from act approved March 3, 1873		$32,723 59	$3,325 61		36,049 20
By act approved June 23, 1874		1,879 54	8,120 46		10,000 00
By act approved March 3, 1875			35,000 00		35,000 00
By act approved August 14, 1876		6,000 00	9,000 00		15,000 00
By act approved June 18, 1878		865 96	29,134 04		30,000 00
By act approved March 3, 1879		400 00	18,360 29	$6,239 71	25,000 00
By act approved June 14, 1880				25,000 00	25,000 00
Total	110,000 00	41,869 09	102,940 40	31,239 71	286,049 20

Original estimate for carrying out present project, not counting the cost of repairs to piers	$269,739 25
Remaining to be appropriated for dredging	134,293 18

Money statement.

July 1, 1879, amount available	$32,264 94	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$57,264 94
July 1, 1880, amount expended during fiscal year	23,156 21	
July 1, 1880, outstanding liabilities	2,869 02	
		26,025 23
July 1, 1880, amount available		31,239 71

Amount (estimated) required for completion of existing project............134, 293 18
Amount that can be profitably expended in fiscal year ending June 30, 1882:
For dredging.. $50, 000 00
For repair of piers 25, 000 00
——— 75, 000 00

Abstract of proposals for dredging the inside harbor of Duluth, Minn., opened August 21, 1879.

No.	Names and residences of bidders.	Names and residences of sureties.	For dredging per cubic yard.
1	Starke, Smith & Co., Milwaukee, Wis..	D. G. Rogers and W. H. Meyer, Milwaukee, Wis	15¾ cents.
2	Williams & Upham, Duluth, Minn	Collector P. McDougall and Wm. L. McLennan, Duluth, Minn	14 cents.

Contractors, Williams & Upham.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels, &c.

Description.	Schooners.	Steamers, screw.	Paddle steamers.	Tonnage.	Number of men.
Arrivals, 1879.					
American vessels from American ports	167	205	1	221, 669	6, 641
American vessels from foreign ports	5	7	......	502	53
Foreign vessels from foreign ports	3	84	30	73, 686	3, 129
Total, 1879	175	296	31	295, 857	9, 823
Total, 1878	59	309	38	266, 914	8, 961
Total, 1877	41	245	43	215, 451	7, 629
Clearances, 1879.					
American vessels for American ports	168	204	1	221, 731	6, 686
American vessels for foreign ports	2	7	......	309	42
Foreign vessels for foreign ports	3	82	30	73, 306	3, 102
Total, 1879	173	293	31	295, 346	9, 830
Total, 1878	58	301	34	65, 263	2, 976
Total, 1877	40	245	43	215, 408	7, 641

Receipts and shipments of freight by lake during the year 1879 at the port of Duluth, Minn.

Commodities.	Freight received.	Freight shipped.	Total.
	Pounds.	*Pounds.*	*Pounds.*
Merchandise	56, 404, 839	11, 912, 833	68, 317, 670
Salt	25, 769, 930	....	25, 769, 930
Railroad and pig iron	68, 320, 000	....	68, 320, 000
Lumber	21, 900, 000	....	21, 900, 000
Coal	105, 570, 310	....	105, 570, 310
Flour	....	102, 238, 400	102, 238, 400
Wheat and corn	....	202, 616, 440	202, 616, 440
Total, 1879	277, 965, 077	316, 767, 673	594, 732, 750
Total, 1878	154, 704, 305	199, 052, 477	353, 756, 782
Total, 1877	131, 398, 175	155, 753, 224	297, 151, 379
Total, 1876	77, 510, 136	192, 676, 050	270, 186, 186
Total, 1875	101, 195, 130	171, 306, 247	272, 501, 377
Total, 1874	70, 319, 089	156, 922, 506	827, 241, 595
Total, 1873	80, 841, 023	165, 349, 713	246, 190, 736
Total, 1872	71, 201, 597	72, 895, 065	144, 097, 662
Total, 1871	61, 574, 219	122, 523, 780	184, 097, 999

Statement of freight forwarded and received by railroad at Duluth for year 1879.

	By Saint Paul and Duluth Railroad.	By Northern Pacific Railroad.	Total.
Commodities forwarded:	*Pounds.*	*Pounds.*	*Pounds.*
Lumber	3, 350, 000	23, 326, 800	26, 676, 500
Salt	18, 405, 600	3, 537, 000	21, 942, 600
Coal	57, 899, 020	40, 304, 130	98, 203, 150
Railroad and pig iron	13, 376, 000	36, 735, 530	50, 111, 530
Merchandise, &c	47, 083, 860	25, 339, 470	72, 423, 330
Total	140, 114, 480	129, 242, 630	269, 357, 110
Commodities received:			
Flour	97, 662, 000	2, 183, 000	99, 845, 000
Merchandise, &c	64, 464, 932	1, 653, 127	66, 118, 059
Wheat	54, 232, 060	112, 986, 438	167, 218, 498
Total	216, 358, 992	116, 822, 565	333, 181, 557

Comparison with previous years.

	Pounds.
1879, total received and forwarded	602, 538, 667
1878, total received and forwarded	354, 974, 561
1877, total received and forwarded	311, 208, 341
1876, total received and forwarded	277, 197, 587

Opening and closing of the harbor at Duluth, Minn.

Year.	Opening.	Closing.
1855	April 15	December 16.
1856	April 16	November 22.
1857	May 27	November 20.
1858	March 20	November 20.
1859	May 25	November 9.
1860	April 7	December 4.
1861	June 12	December 12.
1862	April 28	December 16.
1863	May 10	December 7.
1864	April 23	December 1.
1865	April 22	December 5.
1866	May 5	December 10.
1867	April 19	December 1.
1868	April 1	November 21.
1869	April 25	November 12.
1870	April 12	November 21.
1871	April 5	December 6.
1872	March 9	November 24.
1873	May 10	December 30.
1874	May 2	December 11.
1875	May 12	December 10.
1876	May 2	December 19.
1877	April 25	December 17.
1878	March 23	January 2, 1879.
1879	April 17	December 12.

NOTE.—The principal business of this port is the "in transit" trade between provinces of Quebec, Ontario, &c., and the province of Manitoba. The amount for the fiscal year ending June 30, 1880, is as follows:

Value of merchandise	$1, 326, 746 00
Estimated duties on same	816, 666 45

REPORT OF MR. THOMAS SHIELS, OVERSEER.

SAINT PAUL, MINN., *December* 15, 1879.

SIR: I have the honor to submit the following report of operations for the season of 1879, at harbors of Duluth, Minn., and Superior, Wis.

In accordance with your instructions I proceeded to Duluth on the 24th of April

last. The contractor for dredging was not ready for work, nor did he get ready until May 5. The work at Duluth consisted of dredging in the inner harbor. The amount of material removed under first extension of contract of 1878 was 49,819.02 cubic yards. Under the second extension, August 7 to 25, inclusive, there were removed 23,197 cubic yards. Under the contract of 1879, commencing August 26 and continuing to November 22, when the work was closed, there were removed 95,492.27 cubic yards, making a total for the season in Duluth Harbor of 168,508.29 cubic yards. Twenty-seven thousand one hundred and twenty-seven cubic yards of the above amount were removed from the area north of the canal.

Taking into consideration the immediate development of new enterprises at Rice's Point, namely, the starting of the blast furnace, new docks, and elevator of the Northern Pacific Railroad, and the probable building of several saw-mills in that vicinity, I would recommend that immediate future dredging be done in cutting a channel from the south end of the Northern Pacific docks and running parallel with Rice's Point, connecting with the so-called "new cut" (made this season at the dike). Thus would the work not only be immediately available in the interest of commerce, aiding the new enterprises in that locality, but would also be carrying out the recommendations of the Board of Engineers that met in Chicago April 16, 1873, in whose report you will find the following: "If there should be any funds available, after finishing the said works thus described, they could be applied to dredging a channel in the vicinity of the Duluth docks (marked C D on accompanying tracing, said tracing being No. 70 on file in this office), as such dredging will improve the harbor of Duluth, and will also form a part of the channel from the natural entrance to these docks mentioned in the act of appropriation."

The only other work done at Duluth Harbor this season by me was the placing of 750 feet, board measure, of plank on canal face of bay end of north pier under the new superstructure, and the transferring of some 20 cords of stone from the south to the north pier.

NATURAL ENTRY.

In May last, in accordance with your instructions, I had planted on that portion of Minnesota Point between the old light-house and the end of the point, the following plants:

1,300 slips of willows.
500 slips Balm of Gilead.
300 tufts sand grass.
About one peck Wild Rose seed.

The portion of point above alluded to was, and has been for some years, entirely denuded of vegetation, and the prevailing winds had blown the sand into the bay, until the surface of the point was nearly on a level with the lake. The cost of these plantings was $25. Before the close of the work in November last, I gave these plantings a close examination, and am satisfied that at least 80 per cent. of them are alive and in good growing condition. Already little hummocks of sand are beginning to accumulate around them, and when they have a little more growth, will prove very beneficial in retaining the sand and building up the point. I would suggest that at least an equal amount of planting be done next season, as we have now learned the kind of slips it is best to use.

MINNESOTA POINT PIER.

The only work done on this pier, this season, was the filling of all empty intervals and pockets with rock. The amount of rock used for this work was 35.94 cords, purchased of Martyn Wheeler. I am pleased to be able to report that there has been no settlage of rock in the bulkhead or outer crib since it was filled in 1878, the first time since its construction; that it has passed through the fall and spring storms and not been entirely emptied, the repairs ordered by you to the face of the crib having effectually stopped all leakage.

At a point about 250 feet from the intersection of this pier with the shore there is quite a marked settlage on the north side; yet, up to the present time, there is no particular damage to the work. Should it continue further to settle during the winter and spring it will require attention.

WISCONSIN POINT PIER.

There originally was constructed a revetment about 150 feet long, connecting the inner end of this pier with the shore, and to prevent the action of the back swell during and after a storm from washing behind and undermining the pier. The shore

has been constantly receding; it was found necessary to extend this work to the shore, a distance of 150 feet, which was done during the month of October last. The work consists of timber and log cribbing, 150 feet long, 18 feet wide, and 2 feet deep, on top of which was placed a layer of brush fascines 15 inches in diameter, each bundle staked with two stakes 4 feet long and from 2½ to 3 inches in diameter; the whole topped with a layer of rock about 15 inches deep.

The old portion of the revetment was also repaired by raising the face 1 foot, with timber, and tied with six cross-ties 25 to 30 feet long, and the whole leveled evenly with rock, making a continuous work 300 feet long. The material in this work was as follows:

50 cords rock, purchased of M. Wheeler.
27.27 cords brush fascines, purchased of H. M. Peyton.
15.50 cords rock, transferred from the South Pier, Duluth Canal.
20 old boats on hand.
Timber and logs picked up on the beach adjacent to the work.

This pier is in much the same condition as last reported. In reference to the bulkhead of this pier, I find that there has been no settlage of the filling, and the remarks in reference to the Minnesota pier are equally applicable to this.

NEW CUT.

This work commences at the dike at a point 700 feet east of Rice's Point, and runs south to a connection with the natural channel of the Saint Louis River opposite Peyton's Mills. The funds available for this work being limited, there was only one cut made, leaving when the work was closed a channel of 30 feet in width, with an average depth of from 10 to 11 feet. The amount of material removed was 16,666.76 cubic yards. An equal amount of money to that already spent would give a channel of at least 75 feet wide, with an average depth of 12 feet. There were placed on the end of Rice's and Connor's Points each, two range poles, for the information of those using the channel, which have proved very convenient, buoys being very impracticable, as they were constantly dragged off by boats and rafts.

* * * * * * *

Very respectfully, your obedient servant,

THOMAS SHIELS,
United States Overseer.

Maj. CHARLES J. ALLEN,
Captain, Corps of Engineers, U. S. A.

B B 2.

DREDGING SUPERIOR BAY, WISCONSIN.

Work consisted in the most necessary repairs to piers bordering the entry, and the preservation of Minnesota and Wisconsin Points against the action of waves and winds. For details of work at this and Duluth Harbor during the season of 1879, that is, from May to December, see the appended report of Mr. T. Shiels, overseer of the work. About 17,000 cubic yards of material were also removed along a line in front of Connor's Point, to assist navigation to and from Duluth and Superior for light tugs crossing the submerged dike. This excavation was done by the contractors for the Duluth dredging, and at the same price as for the latter, viz, 12 cents per cubic yard.

The protection crib-work, beach protection wall on Minnesota Point, and protection work at the junction of the pier and Wisconsin Point, are generally in good condition, as is the protection work at "the opening" on Minnesota Point. Waves and wind have, however, started a breach to the eastward of the old opening, which must be closed with brush and stone work.

If the present plan of improvement of the harbor be adhered to the timber of the piers will, at an early date, require renewal above the low-

water line more or less throughout their length, and additional stone filling be required, the cost of which will be not less than $15,000 in addition to at least $10,000 for ordinary repairs to piers, beach, &c.

A survey of the Bay of Superior was made during the season in compliance with section 2, act of Congress, rivers and harbors, approved March 3, 1879, from which to arrive at the best and most economical plan for harbor improvement at the head of Lake Superior. The report, based upon the results of this survey, and referred to elsewhere, is printed as Senate Ex. Doc. No. 153, Forty-sixth Congress, second session. It was ascertained by the survey that some shoaling had occurred in the harbor since 1873, especially at the natural entry.

The original estimate for the improvement of this harbor was—

For construction of piers	$309,716
For dredging	25,000

And there has been appropriated to date $343,383.80, of which $309,282.31 has been expended in construction and maintenance of piers and beach protection, and $24,628.16 for dredging.

The least amount that should be available for the fiscal year ending June 30, 1882, for maintenance and repairs of piers, beach protection, &c., and for renewal of timber work in the piers, is $25,000.

Congress by act approved June 14, 1880, appropriated for—

Improving Superior Bay, Wisconsin: Dredging for improvement of natural entrance and for repairing existing works, five thousand dollars.

With this appropriation and remainder of funds on hand from former appropriations it is proposed to maintain and repair piers, crib, and beach protection, &c., so far as the funds will go.

The harbor of Superior, Wisconsin, is in the collection district of Superior.

There were no arrivals or departures of vessels at this port during the year 1879.

Marquette, Mich., is the port of entry.

The total of revenues collected during the fiscal year June 30, 1880, was, at Superior City, none; in the district of Superior, $12,345.82.

Abstract of appropriations made for improving Superior Harbor, Wisconsin, how expended, &c.

Appropriations.	For use in repairs and beach protection, and not included in original estimate.	Construction and repairs of piers.	Expended in dredging.	Total amount of appropriation.
By act approved March 3, 1867		$63,000 00		$63,000 00
By act approved April 10, 1869		45,000 00		45,000 00
By act approved July 7, 1870		40,000 00		40,000 00
By act approved March 3, 1871		60,000 00		60,000 00
By act approved June 10, 1872		50,000 00		50,000 00
Allotted from act approved March 3, 1873		$41,322 64	$22,628 16	63,950 80
Allotted from appropriation "Repairs of harbors on Northern lakes"	*$5,433 00			*5,433 00
By act approved August 14, 1876	*3,000 00			*3,000 00
By act approved June 18, 1878	*3,000 00			*3,000 00
By act approved March 3, 1879		5,000 00		5,000 00
By act approved June 14, 1880		5,000 00		5,000 00
Totals	11,433 00	309,322 64	22,628 16	343,383 80

* Of these amounts there was expended during June and July, 1879, in dredging in the Bay of Superior, on a line connecting the harbors of Duluth and Superior, the sum of $2,000, making a total of $24,628.16.

Money statement.

July 1, 1879, amount available	7,791 40	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$12,791 40
July 1, 1880, amount expended during fiscal year		3,318 07
July 1, 1880, amount available		9,473 33

Amount that can be profitably expended in fiscal year ending June 30, 1882. 25,000 00 to be expended in repairs to piers, protection of Minnesota and Wisconsin Points, &c.

TRADE AND COMMERCE OF SUPERIOR CITY, WISCONSIN, 1879.

Exports.

Fish, salt and fresh	$5,000 00
Furs, hides, and wool	6,000 00
Hay, wheat, oats, potatoes, &c	8,000 00
Butter, eggs, small fruits, and maple sugar	3,000 00
Cattle, sheep, and horses	4,000 00
Cord-wood, telegraph poles, railroad ties, fence posts	20,000 00
Lumber and shingles	60,000 00
Timber and saw-logs	60,000 00
	166,000 00

Imports.

Merchandise, such as groceries, dry goods, flour, feed, agricultural machinery, mill machinery, working cattle, horses, sleighs, lumbering outfits, &c., $200,000. The timber and saw-logs exported are cut in the forests back of Superior, and are transported to Duluth for manufacture or shipment.

In the exports is included the value of camp supplies for several lumbering firms which operate on the Saint Croix and its tributaries in the southern part of Douglass County, and receive their supplies through Superior, via Duluth.

B B 3.

IMPROVEMENT OF HARBOR AT GRAND MARAIS, MINNESOTA.

The project for the improvement of this harbor consists in dredging within the area bounded by Mayhew's Point and the inner shore-line and the construction of a breakwater of timber and stone to narrow the entrance and afford additional shelter over what now obtains for vessels seeking refuge during storms. The position affords great natural advantages for the construction of a harbor of refuge, the need of such on the north shore of Lake Superior having been long felt.

It was determined, following the appropriation by act of Congress approved March 3, 1879, to perform the dredging by contract and the crib-work by day labor. The appropriation was not, however, made available until late in the season, so that it was impossible to effect any work upon the breakwater.

Advertisements soliciting bids for dredging were duly inserted, and bids opened on the 27th of August, 1879. Messrs. Williams & Upham, of Duluth, were the only bidders, but their prices being reasonable, contract was entered into with them on the 27th of August for the work of dredging.

Dredging commenced on the 8th of September and continued until the evening of the 24th of October, when the fleet returned to Duluth.

An area of about two acres was dredged to a depth of 16 feet below the low-water plane, the quantity of material, viz, gravel, clay, bowlders, and detached pieces of rock removed, being 19,199 cubic yards. It is to be hoped that the work so well begun can be carried to completion, especially on account of the importance of a harbor of refuge on the long stretch of north shore from Duluth to the easterly end of Lake Superior.

The original estimate for the improvement of this harbor was placed at $139,669.40. This estimate was made in 1874, when the cost of labor and material was much more problematical than at present; it has since been much reduced.

Congress, by act approved June 14, 1880, appopriated for—

Improving harbor at Grand Marais, Minnesota: Continuing the improvement, ten thousand dollars.

It is proposed to expend this sum, together with the balance of funds on hand from the former appropriations, in continuing the dredging within the harbor and in the construction of a timber and stone breakwater to narrow the harbor entrance, both classes of work, under the late appropriation, to be done by contract after due advertisement.

The sum of $40,000 can be profitably expended during the fiscal year ending June 30, 1882, towards completing the work.

Mr. S. L. Bayless, overseer in local charge, has conducted the work intrusted to him with fidelity and economy.

This work is in the collection district of Duluth. Duluth, Minn., is the nearest port of entry, at which place the revenue collected during the fiscal year ending June 30, 1880, amounted to $4,964.51.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING HARBOR AT GRAND MARAIS, COOK COUNTY, MINNESOTA.

By act approved March 3, 1879	$10,000 00
By act approved June 14, 1880	10,000 00
	20,000 00

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$20,000 00
July 1, 1880, amount expended during fiscal year		7,577 13
July 1, 1880, amount available		12,422 87
Amount (estimated) required for completion of existing project		119,669 40
Amount that can be profitably expended in fiscal year ending June 30, 1882, to be used for dredging and pier-work		40,000 00

Abstract of proposals for dredging in the harbor of Grand Marais, Minn., opened August 27, 1879.

Number.	Names and residence of bidders.	Names and residence of sureties.	For dredging, per cubic yard.
1	Williams & Upham, Duluth, Minn	Col. P. McDougall and William L. McLennan, Duluth, Minn.	28 cents.

Contractors, Williams & Upham.

COMMERCIAL STATISTICS.

Exhibit of business done in the year 1879 at Grand Marais, Cook County, Minnesota.

Name of vessel.	Home port.	Tonnage.	Times arriving at Grand Marais.
Tug Siskowit	Duluth	25	23
Schooner Alice Craig	do	60	2
Schooner Anaconda	Grand Marais	5	2
Schooner Celt	Ontonagon	12	1
Tug Two Friends	Fort William	22	1
Tug F. L. Danforth	Duluth	30	3
Tug Nellie Cotton	do	30	1
Tug John Martin	do	20	2
Schooner Charlie	Beaver Bay	50	1
Schooner Marko Polo	Bayfield	30	1

	Value.
Freight received:	
32 tons general merchandise	$4,822
Freight shipped:	
10 tons salt fish	600
12 tons fresh fish	750
Furs	1,700

B B 4.

SURVEY OF SUPERIOR BAY, TO DETERMINE THE BEST AND MOST ECONOMICAL PLAN FOR HARBOR IMPROVEMENT FOR THE HEAD OF LAKE SUPERIOR.

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, Minn., April 5, 1880.

GENERAL: I have the honor to present the following report of a survey of the Bay of Superior, made in accordance with the provisions of section 2 of an act of Congress approved March 3, 1879, the provision reading as follows:

Superior Bay, to determine the best and most economical plan for harbor improvement for the head of Lake Superior.

The party for the survey was organized early in August, as soon as possible after the appropriations had been rendered available. The field operations consisted substantially in the necessary triangulation connecting with the base-line of the lake survey; in meanders, soundings, both within and without the bay; cross-sections of Minnesota and Wisconsin points, and hourly gauge readings, and verifications of bench-marks; in fact, all data that could be accumulated for the construction of a comparative map. The soundings, especially, are numerous; less than one-half of them appear on the tracing herewith.

The maps of 1861 and 1873, of this bay, are the ones made use of for comparison with the map of the survey just closed.

The history of the bay and its improvements has been so fully delineated in previous printed reports by my predecessors and myself that it does not seem necessary here to more than refer to it. The ports of Superior City and Duluth are contained in the Bay of Superior, although separated from each other by a dike built in 1871 and 1872, and extend-

ing across the bay from Rice's Point to Minnesota Point, the dike having been built by the city of Duluth as a compromise measure resulting from the protest of the State of Wisconsin against opening the Duluth Canal, the object of the dike being to prevent the diversion of the waters of the Saint Louis River into the canal and from the Natural Entry.

Contours, referred to the low-water of 1873 projected upon the map, show that but little change has taken place in the outer shore line of Minnesota Point since 1861, and that, if anything, it has moved a little seaward since that date. The contrary is manifested by the inner shore line of Minnesota Point, which appears to have been in places eroded considerably, the erosion probably due to change in the direction of the current following the construction of the Duluth Canal. Much of the point, especially near the dike, consists of floating bog. No marked changes are observable in the outer beach. A mean of 1,040 soundings taken in 1873, covering a strip of lake from the Natural Entry to the Duluth Canal, 1,500 feet in width, is 13.704 feet, while a mean of 1,924 soundings, taken over the same area in 1879, is 13.646 feet. As to the changes of depth within the bay, Assistant Frizell, whose report is herewith, says:

As to the depths within the bay, the accord between this and the survey of 1873 is less satisfactory. A mean of 4,408 soundings taken in 1873 gives 8,524 feet. A mean of 4,390 soundings on the same ground taken in 1879, gives 8,017 feet, showing an apparent decrease of depth of 0.507 foot since 1873. I am unable to account for any such extensive shoaling as this result would indicate, and am strongly inclined to ascribe it to an error in the survey of 1873, more especially as I find that the assistant, who made the special survey of the preceding year, was perplexed to account for a *deepening* showed by his survey as compared with that of 1861. I find no record of any discrepancy between the surveys of 1872 and 1873, and if there was an error in the gauges or bench-marks of the former it was probably repeated in the latter. The mean of 561 soundings, taken in 1861 on the same area, reduced to the plane of the present survey, is 7.46. The soundings of 1861 are recorded in full feet without fractions. As it is not probable that any sounding would have been recorded too great (which would mislead navigators), we must assume that the fractional part of every sounding was rejected. This makes the average depth ½ foot too small. The true average depth for 1861 was, therefore, 7.96, which is in substantial agreement with the present survey. The agreement of the soundings outside the harbor indicates that the error, if such it be, does not extend to the two channels of entrance.

The most important fact brought out by the survey is the extent of the scouring action in the Duluth Canal, and the increased depth; and the reverse, to a certain extent, at the Entry. The map of 1873 shows an average depth through the Entry of 13.36 feet, and throughout the canal of 15.59 feet. The present survey shows throughout the Entry an average depth of 12.6 feet, the canal showing 19.4 feet

The scouring action in these channels is due to two causes: 1st, the constantly recurring oscillations of the lake surface, causing both inward and outward currents of considerable velocity through the channels; 2d, the volumes of the Saint Louis and Nemadji rivers, both of which before the opening of the Duluth Canal found egress to the lake through the Natural Entry.

The dike above referred to, flimsily built, has settled out of sight, and large portions of it have been carried away by waves. It is, at present, but a drowned dam of irregular profile, and with large apertures for the passage of water. The extent of its settling will be appreciated when we consider that it was constructed to completely separate the harbors of Duluth and Superior and prevent the diversion of any of the discharge of the Saint Louis River towards the canal, and that at present a section taken along its axis shows an area of 21,600 square feet of water-way, the length of the dike being about 5,000 feet. The distance from the mouth of the Saint Louis River to the mouth of the canal is

11,900 feet, while to the mouth of the Entry it is 27,000 feet. The canal is 1,200 feet long; the length of the Entry, 2,600 feet. The average width of the former is 250 feet, and of the latter, 350 feet. The average cross-section of the canal is, at present, 4,850 square feet; that at the Entry, 4,410 square feet; soundings all referred to the plane of low-water of the winter of 1873. It will be seen that the resistances to the flow of water through the canal are less than at the Entry.

Of a large number of floats placed in the Saint Louis River just above its mouth, a number moved towards the dike, and would have, if they had not been picked up, entered the canal.

The conclusion can hardly be avoided that the opening of the canal and failure to keep the dike in order has caused some deterioration of the channel through the Natural Entry.

That there is a movement of the soft material of the bottom of the bay due to scouring and wave action, and to material brought down the Saint Louis and Nemadji rivers, is undeniable. It has frequently been found necessary to retouch areas that had been previously dredged over to the full depth required.

The act of Congress refers to the best and most economical plan for harbor improvement at the head of Lake Superior to be deduced from the results of the survey. The map from the survey is very complete, and affords basis for estimate for any plan proposed. But before any radical change of plan can be entertained the necessity, expediency, or advantage of such change must be demonstrated by existing commercial interests, lines of wharves, &c., or by at least sufficient surety of the immediate development of such as to put them out of the range of the prospective. There seems little doubt that before long the value of Duluth and Superior City as shipping ports will be largely increased.

The present plan of improvement consists in dredging in the harbor of Duluth in the vicinity of the docks, and the excavation, by dredging, of an anchorage ground to the east of the canal, the dredging to be 16 feet below the low-water of 1873, and such repairs to the piers as may be absolutely necessary; and for the harbor of Superior City, repairs to the piers and preservation of weak points upon Minnesota and Wisconsin Points. Last season a small channel 10 feet in depth was dredged on a line past Rice's and Connor's Points connecting the two harbors.

From the location and direction of the Duluth Canal vessels have not found, during storms, perfect safety in lying at the wharves. The anchorage area now being excavated will admit, when finished, of better protection to vessels under the lee of the point. (See map.) But this question of protection to vessels at anchor is receiving, in large part, its solution in the inauguration last year of a series of private slips normal in direction of length to the general dock lines.

The possibilities of the entire bay for harborage are great, as a glance at the map will show. Probably the time is not far distant when the greater part of the western and southern perimeter of the bay will be faced with docks and wharves, and a large portion also of Minnesota Point. Whenever such obtains, dredging on an extensive scale, and probably on lines parallel to the lines of wharves, will be required, and an assured channel of communication between Duluth and Superior Cities, within the bay, instead of by the outside passage. As it is, but one small vessel of light draught entered the port of Superior last season.

Various plans have been suggested at times by interested parties, viz, to close up the Duluth Canal and excavate another one about 2 miles farther down Minnesota Point at a point directly opposite the mouth of the Saint Louis River; another, to have three openings instead of the

two now existing; a third, to close up both the canal and the Entry and excavate the new channel across Minnesota Point above referred to, also to remove the greater part of the dike, &c.; but in the absence of positive information as to immediate increased wants of commerce, I do not think that any great change from the present plan can be recommended, or even discussed.

Accompanying are statistics of the ports of Duluth and Superior, including list of dates of opening and closing of navigation at Duluth since 1855; table giving force and direction of prevailing winds during 1877, 1878, and 1879, from records of the United States Signal Office; report of Assistant J. P. Frizell; also, two tracings, and one plotting of hourly gauge-readings taken during the survey.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

In the Bay of Superior are included the harbors of Duluth and Superior.

The harbor of Duluth, Minnesota, is in the collection district of Duluth. Duluth, Minn., is the nearest port of entry. The collections for the year 1879 amounted to $5,683.12.

The harbor of Superior, Wis., is in the collection district of Superior.

There were no arrivals or departures of vessels at this port during the year 1879. Marquette, Mich., is the port of entry, at which place there was collected the sum of $10,331.95 for the fiscal year ending June 30, 1879.

DULUTH HARBOR.

Arrivals and clearances of vessels, &c.

	Schooners.	Steamers, screw.	Steamers, paddle.	Tonnage.	Number of men.
Arrivals, 1879:					
American vessels from American ports	167	205	1	221, 669	6, 641
American vessels from foreign ports	5	7	......	502	53
Foreign vessels from foreign ports	3	84	30	73, 686	3, 129
Total, 1879	175	296	31	295, 857	9, 823
Total, 1878	59	309	38	266, 914	8, 961
Total, 1877	41	245	43	215, 451	7, 629
Clearances, 1879:					
American vessels for American ports	168	204	1	221, 731	6, 686
American vessels for foreign ports	2	7	......	309	42
Foreign vessels for foreign ports	3	82	30	73, 306	3, 102
Total, 1879	173	293	31	295, 346	9, 830
Total, 1878	58	301	34	65, 263	2, 976
Total, 1877	40	245	43	215, 408	7, 641

Receipts and shipments of freight by lake during the year 1879 at the port of Duluth, Minn.

Commodities.	Freight received.	Freight shipped.	Total.
	Pounds.	*Pounds.*	*Pounds.*
Merchandise	56, 404, 839	11, 912, 833	68, 317, 670
Salt	25, 769, 930		25, 769, 930
Railroad and pig iron	68, 320, 000		68, 320, 000
Lumber	21, 900, 000		21, 900, 000
Coal	105, 570, 310		105, 570, 310
Flour		102, 238, 400	102, 238, 400
Wheat and corn		202, 616, 440	202, 616, 440
Total, 1879	277, 965, 077	316, 767, 673	594, 732, 750
Total, 1878	154, 704, 305	199, 052, 477	353, 756, 782
Total, 1877	131, 398, 175	165, 753, 224	297, 151, 379
Total, 1876	77, 510, 136	192, 676, 050	270, 186, 186
Total, 1875	101, 195, 130	171, 306, 247	272, 501, 377
Total, 1874	70, 319, 089	156, 922, 506	327, 241, 595
Total, 1873	80, 841, 023	165, 349, 713	246, 190, 736
Total, 1872	71, 201, 597	72, 895, 065	144, 097, 662
Total, 1871	91, 574, 219	122, 523, 780	184, 097, 999

Statement of freight forwarded and received by railroads at Duluth for year 1879.

Commodities.	By St. Paul and Duluth Railroad.	By Northern Pacific Railroad.	Total.
Commodities forwarded:	*Pounds.*	*Pounds.*	*Pounds.*
Lumber	3, 350, 000	23 326, 800	26, 676, 500
Salt	18. 405, 600	3, 537, 000	21, 942, 600
Coal	57, 899, 020	40, 304, 130	98, 203, 150
Railroad and pig iron	13, 376, 000	36, 735, 530	50, 111, 530
Merchandise, &c	47, 083, 860	25, 339, 470	72, 423, 330
Total	140, 114, 480	129, 242, 630	269, 357, 110
Commodities received:			
Flour	97, 662, 000	2, 183, 000	99, 845, 000
Merchandise, &c	64, 464, 932	1, 653, 127	66, 118, 059
Wheat	54, 232, 060	112, 986, 438	167, 218, 498
Total	216, 358, 992	116, 822, 565	333, 181, 557

Comparison with previous years.

	Pounds.
1879, total received and forwarded	602, 538, 667
1878, total received and forwarded	354, 974, 561
1877, total received and forwarded	311, 208, 341
1876, total received and forwarded	277, 197, 587

TRADE AND COMMERCE OF SUPERIOR CITY, WIS., 1879.

Exports.

Fish, salt and fresh	$5, 000 00
Furs, hides, and wool	6, 000 00
Hay, wheat, oats, potatoes, &c	8, 000 00
Butter, eggs, small fruits, and maple sugar	3, 000 00
Cattle, sheep, and horses	4, 000 00
Cord-wood, telegraph poles, railroad ties, fence posts	20, 000 00
Lumber and shingles	60, 000 00
Timber and saw-logs	60, 000 00
	166, 000 00

Imports.

Merchandise, such as groceries, dry goods, flour, feed, agricultural machinery, mill machinery, working cattle, horses, sleighs, lumbering outfits, &c	200,000 00

The timber and saw-logs exported are cut in the forests back of Superior, and are transported to Duluth for manufacture or shipment.

In the exports is included the value of camp supplies for several lumbering firms which operate on the Saint Croix and its tributaries in the southern part of Douglas County and receive their supplies through Superior.

Opening and closing of the harbor at Duluth, Minn.

	Opening.	Closing.		Opening.	Closing.
1855	April 15	December 16.	1868	April 1	November 21.
1856	April 16	November 22.	1869	April 25	November 12.
1857	May 27	November 20.	1870	April 12	November 21.
1858	March 20	November 28.	1871	April 5	December 6.
1859	May 25	November 9.	1872	March 9	November 24.
1860	April 7	December 4.	1873	May 10	December 30.
1861	June 12	December 12.	1874	May 2	December 11.
1862	April 28	December 16.	1875	May 12	December 10.
1863	May 10	December 7.	1876	May 2	December 19.
1864	April 23	December 1.	1877	April 25	December 17.
1865	April 22	December 5.	1878	March 23	January 2, 1879.
1866	May 5	December 10.	1879	April 17	December 12.
1867	April 19	December 1.			

Prevailing direction and total monthly movement of wind at Duluth, Minn.

Year and month.	Prevailing direction.	Total number of miles traveled during the month.
1877.		
January	W.	3,868
February	SW.	4,492
March	NE.	5,031
April	NE.	6,343
May	NE.	4,741
June	NE.	5,698
July	NE.	5,269
August	NE.	4,936
September	E.	5,259
October	SE.	7,119
November	NW.	4,866
December	NE.	5,413
1878.		
January	SW.	4,303
February	NE.	4,634
March	NE.	6,153
April	NE.	7,634
May	NE.	6,011
June	NE.	3,333
July	NE.	4,314
August	NW.	5,442
September	NE.	5,290
October	W.	5,358
November	SW.	4,582
December	SW.	5,609
1879.		
January	SW.	4,990
February	NW.	4,521
March	SW.	5,240
April	NE.	5,227
May	NE.	5,132
June	NE.	5,010
July	NE.	5,567
August	NE.	5,120
September	NW.	4,663
October	SW.	4,748
November	NW. & W.	4,681
December	NW.	6,234

REPORT OF MR. JOSEPH P. FRIZELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, Minn., March 22, 1880.

SIR: The act of Congress approved March 3, 1879, provides for a survey of "Superior Bay, to determine the best and most economical plan for harbor improvement for the head of Lake Superior." In accordance with your directions, I have the honor to

present the following account of this survey, its results, and certain suggestions founded thereon.

The execution of this survey was intrusted to Assistant Engineer E. M. Spalding. He commenced operations early in August, which was as soon as practicable after the appropriation had been made available for expenditure. In accordance with the terms of the act, the survey did not extend to the bays of Saint Louis and Allouez, but was complete and thorough as regards the Bay of Superior. Assistant Spalding has during the winter completed a very accurate and reliable map of the bay; also a comparative map, showing changes since the date of former surveys and a chart of gauge readings, taken at several different points, exhibiting the oscillations of the lake and bay, and the direction of the currents at the canal and Natural Entry during the survey.

The changes due to natural causes exhibited by these maps are worthy of attention. The outer shore line of Minnesota Point is almost identical with that shown on the map of 1861, the only difference being that it appears to have moved a little seaward since the latter date, showing a tendency to accretion instead of wasting. Decidedly the contrary tendency is manifested by the inner shore of Minnesota Point, which has in places moved seaward to a greater extent than the outer.

The present survey is checked on the base lines and monuments of the survey of 1861, so that no serious error could have been committed in the location of these lines.

The wasting of the inner shore is probably due to the change in the direction of the currents produced by the Duluth Canal. It consists largely of floating bog, which is formed in the Bay of Superior and adjacent waters. This is sometimes aggregated in the form of islands, an acre or more in extent, sustaining trees and vegetation. It attaches itself to the shore in large masses, from which it is readily separated by causes that would have no effect on a sandy or gravelly beach.

No change appears to have taken place in the outer beach. The mean of 1,040 soundings taken in 1873, covering a strip of the lake 1,500 feet wide, reaching from the Superior Entry to the Duluth Canal, is 13.704. The mean of 1,924 soundings taken on the same area, in 1879, is 13.646. As to the depths within the bay the accord between this and the survey of 1873 is less satisfactory. A mean of 4,408 soundings taken in 1873 gives 8.524 feet. A mean of 4,390 soundings, on the same ground, taken in 1879, gives 8.017, showing an apparent decrease of depth of 0.507 foot since 1873. I am unable to account for any such extensive shoaling as this result would indicate, and am strongly inclined to ascribe it to an error in the survey of 1873, more especially as I find that the assistant who made the especial survey of the preceding year was perplexed to account for a *deepening* showed by his survey as compared with that of 1861. I find no record of any discrepancy between the surveys of 1872 and 1873, and if there was an error in the gauges or bench-marks of the former it was probably repeated in the latter. The mean of 561 soundings taken in 1861, on the same area, reduced to the plane of the present survey, is 7.46. The soundings of 1861 are recorded in full feet without fractions. As it is not probable that any sounding would have been recorded too great (which would mislead navigators), we must assume that the fractional part of every sounding was rejected. This makes the average depth half a foot too small. The true average depth for 1861 was therefore 7.96, which is in substantial agreement with the present survey. The agreement of the soundings outside the harbor indicates that the error, if such it be, does not extend to the two channels of entrance.

The most important change revealed by this map, as compared with that of 1873, is the great increase of depth in the Duluth Canal, and the entire cessation of scouring action—in fact, positive shoaling—at the Natural Entry. By the map of 1873, the Entry shows an average depth of 13.36 feet; the canal, 15.59. By the present survey the Entry shows an average depth of barely 12.6 feet; the canal, 19.4 feet. These depths are all referred to the stage of water prevailing during the survey of 1873, and are the average of all the soundings recorded on the maps between the piers of the canal and those of the Entry, respectively.

The cause of this change will become apparent on a little consideration. The scouring action in these channels is due to currents caused in part by the waters of the Saint Louis and Nemadji rivers, and more largely by the constantly recurring oscillations of the lake. For the point immediately under consideration it is immaterial which of these agencies contributes most to the scouring action. It is sufficient to say that when the bay stands higher than the lake there is an outward current, and, in the reverse relation, an inward current. The river waters can produce a current in no other way than by raising the water of the bay above that of the lake. There is one difference, however, between the scouring action of a river and that of a current generated by tidal oscillations, which it is well to bear in mind. In the former, an increase of depth diminishes the velocity, and when the velocity has decreased so much as to be incapable of acting on the bed, the scouring ceases.

In the latter, an increase of depth increases the velocity, and the enlargement of the channel does not cease till it has attained such dimensions as to preclude the possi-

bility of any considerable difference of level between the two bodies of water connected by it.

The height of water was noted hourly during the survey at four different points, viz:

1. At a gauge on the north pier of the Duluth Canal toward the outer end, showing the height of water in the lake.
2. At a gauge on the inner end of the same pier.
3. At the Entry.
4. At Peyton's saw-mill on Connor's Point.

The greatest variation of level of the lake was 1.45 feet. The first-named gauge showed that changes as rapid as 12 inches in an hour are to be expected. Major Houston reports the maximum oscillation of the lake as 1.74 feet at the canal; 1.69 feet at the Entry. I assume, for the purpose of comparison, a difference of level of 1 foot between the lake and bay. Let us see how such a head would affect the currents, respectively, at the canal and Entry. Consider, first, the Duluth Canal. Let V represent the velocity in feet per second. The head of 1 foot is expended in 3 ways:

1. In imparting to the water the velocity, V. This part of the head is represented by $\frac{V^2}{2g}$, g being the velocity imparted by gravity in feet per second.

2. In certain commotions imparted to the water at its entrance to the canal resulting from its approaching the entrance in different directions. Assuming 0.85 as the coefficient of contraction on entering the canal, the loss of head from this cause is represented by

$$\left\{\left(\frac{1}{0.85}\right)^2-1\right\}\frac{V^2}{2g}.$$

3. In the frictional resistances to movement in the canal itself.

This I represent by the formula of Hagen,* recently deduced from a comprehensive analysis of all existing reliable measurements of the flow of water in open channels, viz, $V=6\sqrt{r}\sqrt[5]{S}$, in which r = the mean radius, otherwise called the hydraulic mean depth, being the quotient obtained by dividing the cross-section in square feet by the wetted perimeter in linear feet; S = the slope or fall in the canal divided by the length thereof. The length of the canal is 1,200 feet; width, 250 feet; depth, 19.4 feet.

$$r=\frac{250\times 19.4}{250+2\times 19.4}=16.8\ \therefore\ \sqrt{r}=4.1$$

$$S=\frac{1-\frac{V^2}{2g}-\left\{\left(\frac{1}{0.85}\right)^2-1\right\}\frac{V^2}{2g}}{1200}=\frac{1-1.384\frac{V^2}{2g}}{1200}$$

$$V=6\times 4.1\sqrt[5]{\frac{1-1.384\frac{V^2}{2g}}{1200}}$$

whence,

$$V^5+161.53\,V^2=7507.$$

Solving this equation by a process of trial and error, we find V = 5.07 feet per second. Applying the same method to the Entry, where the width is 350 feet, length about 3,000 feet, depth 12.6 feet, we have—

$$r=\frac{12.6\times 350}{350+2\times 12.6}=11.75.$$

$$S=\frac{1-1.383\frac{V^2}{2g}}{3000}$$

$$V=6\sqrt{11.75}\sqrt[5]{\frac{1-1.384\frac{}{2g}}{3000}}$$

whence,

$$V^5+26.39\,V^2=1226.7,\ \text{from which we find } V=3.84.$$

* Untersuchung über die Gleichförmige Bewegung des Wassers, von G. Hagen, Berlin, 1876.

These results explain in some measure the difference in the activity of the scouring process in the two channels. The length of the canal is only two-fifths that of the Entry. This would give the canal the advantage in point of velocity were the two channels of equal depth. Every increase, in depth, however, in the Duluth Canal increases the velocity and abrasive power there, and diminishes the latter at the Entry; since, inasmuch as there is but a certain limited quantity of water to pass from the lake to the bay, or *vice versa*, at each oscillation, the greater the quantity passing the canal the less will be that passing the Entry.

The average cross-section of the canal at present is 4,850 square feet; that at the Entry, 4,410 square feet. In the case supposed of a difference of 1 foot in height between the lake and bay the volume of water passing the canal is 24,589 cubic feet per second, viz, 4,850 × 5.07. That passing the Entry is 16,934 cubic feet per second. The scouring power is proportional to the quantity of water multiplied by the square of the velocity. The scouring power at the canal may, therefore, be represented by 24,589 × 25.70 = 631,937; that at the entry by 16,934 × 14.75 = 249,776. In other words, the scouring power at the Entry is only a little over three-eighths that at the canal.

The dike completed in 1872 by the city of Duluth to shut off the harbor of Duluth from the rest of the bay has no effect upon these calculations, being washed away to that extent that it presents a clear water-way of 21,600 square feet.

The efficiency of the waters contributed by the Saint Louis and Nemadji, as compared with oscillations of the lake in generating curents, may be noticed here. The total watershed of these rivers is about 3,900 square miles. In times of high-water we might expect 2¼ cubic feet per second for each square mile of this area, or a total of a little less than 10,000 cubic feet per second. It would create a velocity of about 1.2 feet per second in the canal; 0.9 foot per second in the Entry. In low-water not more than one-fifth of a cubic foot per second per square mile could be expected, amounting to less than 800 cubic feet per second.

As this survey did not cover the period of high-water in the Saint Louis River, no conclusive results were obtained as to the direction of its waters after passing Connor's Point. Floats were set loose in the river above Connor's Point, and their course marked by intersection of transit lines. The effect of the river current was largely masked by the oscillations of the lake. Most of the floats merely traveled to and fro between the Bays of Saint Louis and Superior. Their courses are delineated on the map. In three cases they took a decided turn toward the canal, having nearly reached the dike when they were picked up by the observers on the approach of darkness. The presumption is that they would have reached the canal had they been permitted.

For the reason stated above, no conclusive information was obtained as to the quantity of sediment contributed by the rivers. That large quantities of earthy matter are annually brought in is evidenced by the floating bogs already referred to, as well as by the character of the dredgings, especially at the points most remote from the canal, at Duluth, where shoaling has taken place after being once dredged to sufficient depth. Here the deposits consist largely of matters brought down by the rivers.

It is evident that before the opening of the Duluth Canal the waters of the Saint Louis pursued a pretty straight course from Connor's Point to the Entry, that line being occupied by a broad channel from 14½ to 25 feet deep, while the general depth of that part of the bay is but 8 or 9 feet. The cutting of the canal has undoubtedly had the effect to divide this current. A part goes toward the canal, and, on reaching the deep water of the dredged area, deposits a good deal of sediment. The Saint Louis is the main stream entering the bay, having a drainage area of some 3,400 square miles, while the Nemadji has but 500. It is to be remarked that the channel, from Connor's Point to the Entry, is not due wholly to the waters of the Saint Louis River, but largely to the influx and efflux between the lake and the Bay of Saint Louis.

Some inconvenience has been experienced, during storms, at the Duluth wharves from the action of waves, which, owing to the shortness and depth of the canal, are transmitted through it in sufficient force to prevent vessels, at times, from lying at wharves near the line of the canal. This difficulty may be expected to increase with the depth of the canal, and certainly with any increase of its width.

The section of the act of Congress above referred to, authorizing this survey, calls for "estimates of improvements proper to be made" at this point among others. The object of the survey is also stated to be "to determine the best and most economical plan for harbor improvement for the head of Lake Superior." This appears to call for suggestions as to such a plan for improvement, a plan or policy of improvement which may be permanently adhered to hereafter.

Let us first consider the project of leaving the harbor in its present condition as to entrances. The preceding considerations suggest some of the difficulties to be expected in permanently maintaining two channels of entrance. Any slight difference in the velocity and abrasive power of the current tends to increase without limit. Any enlargement of the one strengthens the agency that produces the enlargement, and weakens the agency on which the existence of the other depends. Such a system con-

stitutes what is known in mechanics as a case of unstable equilibrium, wherein any accidental preponderance of one of the forces sets in motion causes that carry the system further and further from the condition of equilibrium.

Judging from the changes that have occurred since 1873, it is entirely probable that were these two channels henceforth left entirely to the control of natural agencies, we should at the end of twenty-five years find the canal enlarged much beyond its present dimensions, the Entry entirely closed.

Harbor entrances formed by piers are exposed to a danger which requires a number of years for its development. The pier arrests the movement of the drift along the shore, and a bank or shoal forms along the outside of the pier. When this shoal reaches the end of the pier, the drift is no longer arrested, but passes freely into the channel. The removal of such deposits by dredging, while it cannot be pronounced impossible, is attended with great difficulty on account of the waves. The surest guaranty of the permanence of such a channel is a powerful current. For these reasons it appears to me that no project involving the maintenance of two channels of entrance, both communicating freely with the bay, will stand the test of years.

Next let us consider the project of discontinuing the Entry and maintaining the canal.

Apart from considerations of equity and justice, I perceive the following objections to this plan:

1. This entrance is not wide enough for such a harbor as the Bay of Superior promises to become. Safety of ingress and egress demands a wider channel, and the currents due to the extent of the inland basins are capable of maintaining a wider one if confined thereto. The difficulties already felt, however, from the ingress of waves admonish us that any material widening of this entrance would be extremely hazardous, liable to defeat the main purpose of a harbor, viz, protection from the waves. The trouble would of course be confined to the wharves in that part of the harbor.

2. The whole volume of the Saint Louis would, under this arrangement, reach the canal by passing over the deep water of the anchorage under conditions most favorable for the deposit of sediment, thereby greatly increasing the difficulties, already sufficiently grave, resulting from this cause.

The rebuilding of the dike may next be considered. This would undoubtedly be of benefit to the Entry. It would confine to this channel the entire discharge of the rivers, which alone are capable of producing at times a velocity of something over 2 feet per second therein. If it did not much increase the velocity of the currents through the Entry, due to fluctuations of the lake, it would prolong their duration, since it would require a longer time for the harbor to adjust itself to a change in the level of the lake. From the great length of the Entry channel, however, the scouring action there could not be expected to equal, under any circumstances, that manifested in the Duluth Canal.

But before constructing this dike in the expectation that it will permit the maintenance of two channels of entrance, let us see what its effect would be upon the Duluth Canal. The dike will inclose at the most a basin of some 40,000,000 square feet, from which the river waters are wholly excluded. Assuming, as above, that the most rapid oscillation of the lake is at the rate of 1 foot in an hour, the greatest velocity through the canal would be that which raised or lowered the basin at the same rate, viz, the velocity required to discharge 40,000,000 cubic feet in an hour, or about 11,000 cubic feet in a second. The cross-section of the canal being 4,850 square feet, the velocity will be 2.29 feet per second. This velocity will fill the basin as fast as the lake rises, and empty it as fast as the lake falls, and therefore cannot be exceeded.

Such a velocity would, in my opinion, be wholly inadequate to keep the entrance to the canal free from the sand and gravel constantly brought into it by the waves. The scouring force in any channel is proportional to the cube of the velocity therein. The effect of a close dike would therefore be to reduce this force in the proportion of $(5.07)^3$ to $(2.29)^3$, that is to one-eleventh of its present intensity.

Wholly different is the case when the canal stands in communication with the entire harbor, containing 395,000,000 of square feet of water surface. For this surface to fluctuate at the rate of 12 inches an hour, would require the discharge of 110,000 cubic feet per second.

The separation of the Bay of Superior into two mutually inaccessible basins has been justly regarded as a very questionable proceeding, and one likely to prove intolerably vexatious in a more advanced stage of development of the harbor. For this reason projects have been brought forward for a dike with a gate to be opened for the passage of vessels. Such an arrangement would be liable to serious objections. The gate could only be opened and closed in safety when the two basins were very near the same level. The time for opening could not be foreseen and calculated on as in the case of a tide gate.

Vessels desiring to use it would be liable to delays of several hours' duration in awaiting the proper stage of water. The only practicable method of admitting the passage of vessels through the dike, while arresting that of water, would be by means of a lock—a plan too expensive for consideration.

The arrangement of the dike best entitled to consideration would consist in providing it with a free opening lined with crib-work at the sides, and protected at the bottom against inordinate deepening. Such a disposition would greatly moderate the velocity through the canal, since the head now wholly employed in producing the velocity in the canal would be divided into two parts, one acting at the canal and one at the opening in the dike. The weakening of the current through the canal would have for its natural consequence the strengthening and prolonging of that through the Entry. It might be possible in this manner to so apportion the current to the two channels as to permanently maintain both. A good deal would depend upon the proportions of the opening through the dike. Its effect in weakening the current through the canal would be increased by diminishing its width or depth, or by increasing its length. Its proper adjustment to the several conditions of the problem is a matter of detail which need not be entered into here.

Such an opening was made in 1873, in the dike built in 1871, and is represented on the map. It was apparently about 75 feet wide. No precautions were taken against excessive deepening. The depth rapidly increased to 30 feet, and would probably have continued to increase had it not been for the extensive demolition of the dike. Such a dike offers the best prospect of permanently maintaining both channels. Its value as a highway, forming the only land connection between the long line of Minnesota Point and the main land, is a consideration of no trifling importance. There would be no objection to the construction of a draw-bridge over the opening when required.

It must be conceded, however, that the permanence of the Entry as a self-sustaining channel cannot be *assured* by any measure short of the filling up of the Duluth Canal, or the construction of a solid dike as near the canal as possible. The former dike, had it been effective, would have injured the Entry to the extent of abstracting about one-tenth of the inland basin on which its preservation depends.

Aside from the question of entrance, the requirements of the bay are sufficiently plain. If it fulfills the promise of its geographical position, the shores of the bay along Connor's Point, Rice's Point, and the long line of Minnesota Point will, in time, be occupied by wharves, warehouses, elevators, coal-yards, blast furnaces, rolling-mills, foundries, saw-mills, lumber-yards, and other establishments requiring water frontage. The works of improvement required within the bay are the extension of deep-water channels along these lines, and the dredging of anchorage ground at one or more points, according to the necessities of commerce. The peninsulas of Minnesota and Wisconsin Points must be carefully watched and any threatened breach averted. The planting of shrubbery and herbage promises to be of benefit in this regard. Dock lines, limiting the extension of solid structures, should be laid out as fast as necessary and rigidly adhered to.

In a purely engineering point of view, the question of entrance is simple enough. The Bay of Superior, considered as a harbor, requires one entrance, and only one. Two entrances are demanded only by local interest, prejudice, and rivalry. It may be assumed that these considerations will diminish in strength with the lapse of time and the development of the harbor. I therefore suggest that the improvements undertaken here be shaped with a view to the ultimate suppression of the Duluth entrance, or of both the present entrances, and the substitution of a new one.

The only step to be immediately taken in this connection is the rebuilding of the dike. It should be built without openings, but with provision for the introduction of one or more at a future time; in the mean time, only temporary repairs to be executed on the Duluth piers. The evil effects of the dike upon the canal will not naturally become apparent under several years, when, it is to be presumed, that a depth will have been attained at the Entry sufficient for the wants of commerce. If no shoaling takes place in the canal, the arrangement may continue, involving no greater inconvenience than the division of the bay. If the canal threatens to become impassable, either of three courses will be open for adoption.

1. Fill up the canal and remove a sufficient portion of the dike.
2. Make an opening or openings in the dike for the experimental attempt to maintain both channels, as indicated above.
3. Fill up both entrances and excavate a new one about 1¾ miles south of a point opposite the extremity of Rice's Point.

This latter method will offer several advantages. The channel need not be any longer than the Duluth Canal. It could be wider than either of the present channels, since experience shows that he scouring forces due to the fluctuations of the lake and the extent of the inland basins would maintain a channel of this length 400 or 450 feet wide. No trouble need arise from the influx of waves, as no wharves need be erected in the vicinity. It would give a direct outlet to the waters of the Saint Louis River, instead of distributing them over the harbor to deposit their sediment in the channels and anchorages. The distance of the new outlet from the bay of Saint Louis would be less than half that of the Entry, and we are entitled to assume that the ebb and flow would maintain this channel since it formerly maintained the much

longer channel from the bay of Saint Louis to the Entry. Entering the bay at about the middle point of its length, this channel would utilize the scouring forces to a greater extent than either of the present, since both the influent and effluent waters would be exposed to less loss of head.

A careful estimate has been made of the cost of a dike to be 24 feet wide on top, with riprapped slopes of 3 to 1, a row of sheet piling through the center, and provision for a future opening 200 feet wide, lined with piers and protected at bottom by brush and rock work. The cost, including 15 per cent. for contingencies and engineering, amounts to $77,318.

Very respectfully, your obedient servant,

JOS. P. FRIZELL,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

APPENDIX C C.

HARBORS ON LAKE SUPERIOR (EAST OF SUPERIOR CITY); ON GREEN BAY, AND ON THE WESTERN SHORE OF LAKE MICHIGAN, NORTH OF MILWAUKEE, WISCONSIN.

REPORT OF MAJOR HENRY M. ROBERT, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., July 7, 1880.

SIR: Herewith I have the honor to transmit my annual report of operations at the several works in my charge during the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

HENRY M. ROBERT,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

C C 1.

IMPROVEMENT OF ONTONAGON HARBOR, MICHIGAN.

Estimated cost of completing the improvement (consisting of two piers, each about 2,500 feet long, and dredging between them) was	$363,770
Appropriated since	217,600
Amount to be appropriated	146,170
Amount that can be profitably expended in the fiscal year 1881-'82	60,000

The work already done consists of about 750 linear feet of pile-pier and revetment and 2,690 linear feet of crib-work The channel between the piers carries a depth of 12½ feet at extreme low-water; but at and in the vicinity of the entrance the bar reduces the low-water depth to about 10½ feet. This bar cannot be economically removed by dredging, since its reformation ensues at each freshet. The prompt extension of the piers should be relied upon to remove this difficulty; and I would therefore recommend that no further specific appropriation be made for dredging, since the amount on hand to be specifically applied to dredging is sufficient; and that future appropriations be made entirely available for pier extension.

The operations during the past year have consisted entirely in pier extension. Three additional cribs were placed on the west-pier extension, under the contract of C. P. MacDougall.

Under the contract of August 26, 1879, with MacDougall and McLennan, four cribs were placed in extension of the west pier, and super-

structure was built over nine cribs, six of which being in the east pier, and three in the west pier.

The contractors should have put down three more cribs by June 30, 1880, and at this writing they are built, and awaiting a favorable opportunity to be sunken. The time for completion of the work has been extended thirty days, or to July 30, 1880.

The operations for the present season will consist in placing the three cribs, under the present contract; and under a new contract, the building of partial superstructure over seven cribs, and the construction and placing of six cribs in extension of the piers. Also, the removal, by hired labor, of the remains of cribs (now obstructing the mid-channel) originally placed by private enterprise, in the early history of the harbor. It is proposed to effect their removal by aid of explosives and dredging.

Continuation of the pier extension is the work contemplated during 1881-'82.

The requirements of the general lake commerce, and the availability of this point as a harbor of refuge when a sufficient depth has been obtained over the outer bar, justify a renewal of previous recommendations concerning sufficient appropriations for the prosecution of the work.

Money statement.

July 1, 1879, amount available	$23,494 66	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$38,494 66
July 1, 1880, amount expended during fiscal year, less $992.15 outstanding July 1, 1879	15,887 34	
July 1, 1879, outstanding liabilities	929 59	
		16,816 93
July 1, 1880, amount available		21,677 73
Amount (estimated) required for completion of existing project		146,170 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		60,000 00

Abstract of proposals opened August 19, 1879, by Maj. Henry M. Robert, Corps of Engineers, U. S. A., for improving harbor at Ontonagon, Mich.

Material.	Quantities.	Orville J. Jennings, Fulton, N. Y. — Rate.	MacDougall & McLennan, Duluth, Minn. — Rate.
Pine timber, 12 by 18 inches, framed ... linear feet	400	$0 36	$0 25
Pine timber, 12 by 12 inches, framed ... do	22,000	24	17
Pine plank, 3 by 12 by 15 inches, laid ... feet, b. m.	32,000	18 00	13 00
Iron drift bolts, 1¼-inch square ... pounds	32,000	03	03
Iron screw bolts, N. and W ... do	100	05	04
Iron wrought spikes, 9-inch ... do	1,700	05	06
Stone ... cords	600	6 50	6 79
Brush ... do	90	2 50	2 75
Total approximate value		11,175 00	9,643 50

Abstract of contracts at Ontonagon Harbor, Mich., during the fiscal year ending June 30, 1880.

Name of contractor and residence.	Contract for—	Remarks.
Col. P. MacDougall, Duluth, Minn.	Pier extension	Closed August 18, 1879.
MacDougall & McLennan, Duluth, Minn.	do	Not closed; work in progress.

List of materials and labor used at Ontonagon Harbor, Mich., in construction of 3 cribs, each 50 by 20 by 13½ feet, under contract with Col. P. MacDougall, dated August 8, 1878.

Articles.	Quantity.	Price.	Amount.
Pine timber, 12 by 18 inches, framed ... linear feet..	300	$0 18	$54 00
Pine timber, 12 by 12 inches, framed ... do....	9,447	18	1,700 46
Stone filling ... cords..	347.6	8 45	2,937 22
Brush filling ... do ...	27.1	2 75	74 52
Drift bolts ... pounds..	13,944.4	02¾	380 78
Screw bolts and washers ... do....	1,013	06	60 78
Total cost of 3 crib substructures			5,207 76
Cost of each crib substructure			1,735 92

NOTE.—The materials used under the contract with MacDougall & McLennan are not reported, the contract not being finished at this writing.

COMMERCIAL STATISTICS.

Name of harbor, Ontonagon, Mich.
Collection district, Superior, Mich.
Nearest light-house, Ontonagon, Mich.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	83	51,460	1,909	83	51,460	1,909
Sailing vessels	6	1,000	33	6	1,000	33
Total	89	52,460	1,942	89	52,460	1,942

Exports during the year ending December 31, 1879.

Copper	tons..	650
Copper, mass	pounds..	318,600
Copper, barrel	do....	981,400
Fish	do....	20,000
General merchandise	tons..	70
Hay	do....	40
Hides	pounds..	16,000
Kaolin	tons..	300
Lumber	feet, b. m..	3,000,000
Shingles	number..	2,800,000

Imports during the year ending December 31, 1879.

Apples	barrels..	520
Cattle and sheep	head..	100
Coal	tons..	60
Corn	bushels..	3,350
Flour	barrels..	3,063

General merchandise ....tons..	801
Grain ....bushels..	11,260
Hogs ....number..	102
Horses ....do....	30
Lumber ....feet, b. m..	26,000
Lime ....barrels..	226
Pork ....do....	486
Powder and other explosives ....pounds..	32,500
Salt ....barrels..	120
Sugar ....do....	278
Whisky ....do....	13

The above information was obtained from James Mercer.

C C 2.

IMPROVEMENT OF EAGLE HARBOR, MICHIGAN.

This work is completed as far as the demands of commerce seem to warrant its improvement. The expenditure during the year was on account of previous operations. The available funds will be applied to such repairs as may be necessary for the preservation of the cribs.

Money statement.

July 1, 1879, amount available	$4,014 73
July 1, 1880, amount expended during fiscal year, less $81.25 outstanding July 1, 1879	14 73
July 1, 1880, amount available	4,000 00
Amount (estimated) required for completion of existing project	176,362 36

C C 3.

IMPROVEMENT OF MARQUETTE HARBOR, MICHIGAN.

Original estimate (Report of Chief of Engineers, 1866, III 8, IV 81)	$385,129 58
Amount appropriated	298,230 00

The breakwater has been extended to a length of 2,010 linear feet, or 10 feet longer than originally intended. Its cost, including repairs to date, has been about $92,000 less than originally estimated. In September a vessel collided with the breakwater; the slight repairs rendered necessary were at once made.

The settlement of the crib filling has not appreciably increased, and since the integrity of the work seems in no manner threatened by the present condition of the filling, and as the deck planking would be largely destroyed by being taken up, it is deemed best to defer the work of refilling until the planking requires renewal, and available appropriations will permit a thorough refilling and replanking of the entire work.

The exposed position of the work, and the necessity for prompt repairs, makes it desirable to always have on hand available funds to meet contingencies. The breakwater should eventually be extended 400 linear feet, at an estimated cost of $68,000.

Money statement.

July 1, 1879, amount available	$4,036 04	
Amount appropriated by act approved June 14, 1880	1,000 00	
		$5,036 04
July 1, 1880, amount expended during fiscal year		29 68
July 1, 1880, amount available		5,006 36
Amount (estimated) required for completion of existing project (not begun)		68,000 00

COMMERCIAL STATISTICS.

Name of harbor, Marquette, Mich.
Collection district, Superior, Mich.
Nearest light-house, Marquette, Mich.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	204	189,933	....	203	189,297	....
Sailing vessels	470	241,911	....	469	241,311	....
Total	674	431,844	....	672	430,608	....

Exports for the year ending December 31, 1879.

Berries	bushels	2,886
Fish	pounds	120,600
Flour	barrels	40
Hides	pounds	211,490
Household goods	do	80,660
Iron, bar	do	3,000
Iron, scrap	do	1,294,230
Iron ore	tons	514,406
Iron, pig	do	8,327
Lime	barrels	115
Lumber	feet, b. m.	7,700,000
Machinery	pounds	12,950
Miscellaneous	do	118,250
Oil	barrels	4
Potatoes	bushels	80
Powder and other explosives	pounds	370,520
Rags	do	20,640
Stone	tons	2,052
Stoves	number	10
Tallow	pounds	5,650
Whisky	barrels	37
Shingles	number	3,500,000
Hogs	pounds	80,000
Quartz	tons	3,393

Imports for the year ending December 31, 1879.

Apples	barrels	4,707
Blinds	bundles	20
Brick	M	34
Cattle and sheep	number	114
Cider	barrels	200
Coal	tons	25,600
Dry goods	pounds	301,060
Feed	do	1,604,450

Flour	barrels..	2,057
Grain	bushels..	7,328
Groceries	tons..	4,531,280
Hay	do...	660
Hogs	number..	136
Horses	do....	86
Iron and steel	pounds..	2,357,650
Leather	do....	5,560
Lime and cement	barrels..	5,623
Machinery	pounds..	295,270
Malt	do....	121,500
Merchandise, general	tons..	1,265
Nails	pounds..	387,620
Oil	barrels..	2,612
Provisions	pounds..	758,160
Powder and other explosives	do....	354,180
Salt	do....	457,800
Stoves	number..	402
Stone	tons..	2,065
Beer	barrels..	2,022
Whisky	do....	452
Wood	cords..	1,000
Vegetables	pounds..	152,800

The above information was obtained from C. Y. Osborn, collector.

C C 4.

CONSTRUCTION OF HARBOR OF REFUGE AT GRAND MARAIS, MICHIGAN.

The river and harbor appropriation act approved June 14, 1880, appropriated the sum of $10,000 for this work.

The examination made by Maj. D. C. Houston, in 1871, resulted in the submitting of three estimates for the improvement, varying from $167,707 to $481,525 (Report of the Chief of Engineers for 1871, pages 37 and 129).

I would recommend that the small sum available be not expended until further appropriations by Congress accumulate to the amount of at least $50,000, without which an economical commencement of work cannot be made.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	80,000 00

C C 5.

IMPROVEMENT OF MANISTIQUE HARBOR, MICHIGAN.

An examination of this harbor was made in November, 1879, under the provisions of the river and harbor act of March 3, 1879; and, a report submitted, recommending the appropriation of $6,000 for dredging.

The sum of $5,000 was appropriated by the act of June 14, 1880, and will be applied during the present season to this purpose.

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00
Amount (estimated) required for completion of existing project	1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	1,000 00

COMMERCIAL STATISTICS.

Number of vessels which entered the port during 1879, about 45 steamers and 80 sailing vessels.

Value of shipments in 1879	$200,000 00
Value of receipts in 1879	150,000 00

This information was furnished by Mr. W. M. Colwell, of Manistique, Mich.

C C 6.

IMPROVEMENT OF MENOMONEE HARBOR, MICHIGAN AND WISCONSIN.

Estimated cost of extending piers to 16-foot curve in Green Bay, with dredging a channel 14 feet deep between the piers	$212,000
Appropriated to date	163,000
Amount to be appropriated	49,000
Amount that can be profitably expended in fiscal year 1881-'82	40,000

The operations during the past fiscal year consisted in building superstructure over three cribs sunk in 1878, and in sinking six cribs in the further extension of the north pier. The work was done by contract with the Green Bay Dredge and Pile Driver Company. The work already accomplished by the expenditures made consists of about 585 linear feet of slab pier, 2,540 linear feet of pile pier, 700 linear feet of crib pier, and 199,378 cubic yards of material dredged from the channel between the piers. The north pier has a present extension of 550 feet beyond the south pier; this has been done to confine the river currents until the outer bar was reached, and has resulted in maintaining a channel, without dredging, along the north pier. Future pier extension will be on the south side.

The operations contemplated during the present season are the building and sinking of 5 cribs more or less in extension of the south pier and the partial construction of superstructure over the 6 cribs sunk in 1879-'80, and such dredging, refilling of cribs, and repairs as may be necessary.

A continuation of the pier extension is the work contemplated during the season of 1881-'82.

Money statement.

July 1, 1879, amount available	$12,430 61	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$22,430 61
July 1, 1880, amount expended during fiscal year	6,250 08	
July 1, 1880, outstanding liabilities	6,180 53	
		12,430 61
July 1, 1880, amount available		10,000 00
Amount (estimated) required for completion of existing project		49,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		40,000 00

Abstract of contracts at Menomonee Harbor, Michigan and Wisconsin, during the fiscal year ending June 30, 1880.

Name of contractor and residence.	Contract for—	Remarks.
Green Bay Dredge and Pile-Driver Company, Green Bay, Wis.	Pier extension..	Closed July 3, 1880.

List of materials and labor used at Menomonee Harbor, Michigan and Wisconsin, under contract with the Green Bay Dredge and Pile Driver Company.

Articles.	Contract price.	Quantities and cost.		Amount.
		Superstructures, over three cribs.	Six-crib substructures.	
Pine timber, 12 by 18 and 12 by 12 inches ....linear feet..	$0 21	3, 974	20, 886	$5, 220 60
Oak ....M ft. b. m..	30 00	....	7, 920	237 60
Plank ....do....	9 50	7, 000	13, 100	190 95
Piles ....linear feet..	15	....	1, 824	273 60
Stone ....cords..	4 50	95. 36	704. 38	3, 598 83
Drift-bolts..........pounds..	03½	6, 200	26, 378. 8	1, 140 26
Screw-bolts..........do....	04¾	....	4, 754. 95	225 86
Spikes..........do....	04	375	914. 44	51 58
Total cost..........	....	$1, 562 16	$9, 377 12	10, 939 28

NOTE.—Four crib-substructures were each 50 by 20 by 12½ feet, and two crib-substructures were each 50 by 20 by 14½ feet. Each superstructure was 50 by 20 by 5 feet.

Cost of superstructure per linear foot $10. 42
Cost of substructure, 12½ feet high, per linear foot.......... 29. 65
Cost of substructure, 14½ feet high, per linear foot.......... 34. 48

COMMERCIAL STATISTICS.

Name of harbor, Menomonee, Mich. and Wis.
Collection district, Superior, Mich.
Nearest light-house, Menomonee, Mich.

Arrivals and departures for the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	402	189, 406	6, 252	396	190, 056	6, 332
Sailing vessels..........	638	178, 462	3, 902	638	178, 540	4, 080
Total	1, 040	367, 868	10, 154	1, 034	368, 596	10, 412

Exports for year ending December 31, 1879.

Fish ....packages.. 16, 233
Laths ....number.. 25, 175, 000
Lumber..........feet, b. m.. 196, 250, 000
Machinery, value of $75, 000

Pickets	number..	1,284,000
Pig-iron	tons..	3,280
Posts	number..	55,000
Shingles	do....	16,000,000
Ties	do....	1,500
Telegraph-poles	do....	5,000
General merchandise	tons..	200

Imports for the year ending December 31, 1879.

Beef	barrels..	2,986
Brick	number..	1,540,000
Feed	tons..	462
Flour	barrels..	6,534
Coal	tons..	300
Cattle	number..	500
General merchandise	tons..	2,524
Grain	bushels..	119,200
Hay	tons..	1,327
Horses	number..	200
Lime	barrels..	6,125
Pork	do....	4,060
Potatoes	bushels..	2,240
Salt	barrels..	2,012
Stone	cords..	720
Wood	do...	6,660

The above information was obtained from J. C. Sherman, deputy collector of customs, Mr. William Sommerville, and mill companies generally.

C C 7.

IMPROVEMENT OF GREEN BAY HARBOR, WISCONSIN.

Estimated cost of present plans (1872–1874) with small annual appropriations for preserving harbor	$75,000
Appropriated since	63,000
Amount to be appropriated	12,000
Amount that can be profitably expended in fiscal year 1881–'82	12,000

Operations during the past fiscal year consisted of dredging, so as to widen the channel between the mouth of Fox River and the cut through Grassy Island. The work was done under contract with the Green Bay Dredge and Pile Driver Company at the rate of 26 cents per cubic yard, scow measurement.

The contractors began work October 1, completing their contract October 31, and removing 12,571$\frac{8}{10}$ cubic yards, being to the full extent of available funds. The work began at a point about 4,000 feet south of the cut through Grassy Island and extended from thence about 2,100 linear feet towards the mouth of Fox River.

The cut through Grassy Island is separated from the mouth of Fox River by a distance of over 1½ miles; at about the middle of this distance a deflection of about 12° occurs in the direction of the channel. Its length, narrowness (200 feet), and change of course make its navigation very difficult. Piles have been frequently driven to define the channel, but they are removed each season by the ice. It would seem that the improvement should include some method of plainly marking the channel, and a special report covering this subject will be submitted.

During the present season dredging in continuation of the improvement of the channel will be carried on to the extent of available funds.

Continuation of dredging is contemplated in 1881-'82, so as to ultimately connect the mouth of the river with deep water in the bay by a channel 200 feet wide and 14 feet deep.

The importance of this work is urged on account of its connection with the large local interests of Green Bay, and also as the outlet to the commerce likely to result from the improvement of the Fox and Wisconsin rivers.

Money statement.

July 1, 1879, amount available	$4,050 52	
Amount appropriated by act approved June 14, 1880	6,000 00	
		$10,050 52
July 1, 1880, amount expended during fiscal year		4,049 04
July 1, 1880, amount available		6,001 48
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		12,000 00

Abstract of contracts at Green Bay Harbor, Wisconsin, during the fiscal year ending June 30, 1880.

Name of contractor and residence.	Contract for—	Remarks.
Green Bay Dredge and Pile Driver Company, of Green Bay, Wis.	Dredging	Closed October 31, 1879.

C C 8.

HARBOR OF REFUGE AT ENTRANCE TO STURGEON BAY CANAL, WISCONSIN.

Original estimated cost for extending the piers to the 18-foot curve with dredging between the piers	$180,000
Appropriated since	120,000
Amount to be appropriated	60,000
Amount that can be profitably expended in fiscal year 1881-'82	40,000

Operations during the past fiscal year have consisted in building and sinking 11 cribs, 4 in extension of the north and 7 in extension of the south pier; also the replacing of the crib from the north pier which was moved from its place by the winter storms of 1878-'79.

The two outer cribs were covered with plank, and the whole work thoroughly filled and riprapped with stone. This work was done under the contract with Messrs. Truman and Schroeder.

Two hundred and ten linear feet of brush revetment was placed at the inner ends of the pile-piers by hired labor and purchase of materials in open market. The work was experimental, its object being to render the pile-piers sand-tight near their inner ends, and, while successful in stopping the passage of sand through the piers, it was not able to withstand the battering and destructive action of logs and ice. It will be replaced by the sheet-pile revetment.

The project for rendering 1,588 linear feet of pile-pier, sand-tight by means of a sheet-pile revetment was submitted under date of August 7, 1879. It was therein proposed to begin this work "at such time as the Sturgeon Bay and Lake Michigan Ship-canal and Harbor Company shall proceed to dock or revet their property fronting on the harbor, and to continue the same as rapidly as the company's work progresses." In

the present month, the company having made satisfactory arrangements towards the immediate commencement and prompt construction of the docking along the harbor front, preparations were made for beginning operations on the part of the United States, and this work was commenced on June 20, by hired labor and purchase of materials in open market.

The methods adopted were those already so successfully used at Two Rivers and Ahnapee. At the close of the fiscal year 154 linear feet of double sheathing had been placed on the north pier. The contract for the extension of the piers by building and sinking 3 cribs in extension of each pier, together with the construction of about 330 linear feet of guide-piling, was awarded February 23, 1880, to Messrs. McDonald & Boalt. Work was commenced under this contract June 12, 1880. At the close of the fiscal year the piling for the cribs of both piers had been driven, and stone beds laid over the proposed sites of the 6 cribs. The work of framing the cribs and delivery of stone for crib filling had commenced.

With the work completed last season, under the contract with Messrs. Truman & Schroeder, the piers had attained an extension of 1,194 feet on each side, of which 794 feet was pile pier and 400 feet crib pier. This extension carried the piers about 30 feet beyond the point contemplated in the original project of 1871. Since 1871 the bar formation at the entrance between the piers has produced shoaling of about 2 feet.

On January 5, 1880, I submitted the following supplementary project to the Chief of Engineers:

In accordance with the project submitted April 10, 1879, for an expenditure of a portion of the appropriation of March 3, 1879, for improving harbor of refuge at entrance of Sturgeon Bay Canal, Wisconsin, and your letter of approval (972 R. and H. '79), dated May 20, 1879, I have the honor to submit the following project for the expenditure of the remainder of that appropriation.

The project of last spring provided for building, with hired labor, superstructure over the 4 cribs sunk in 1878, and over all the cribs to be sunk in 1879, at an estimated cost of $15,000; the work to be partially done this season, and to be completed next season. The sinking of the cribs was so much delayed by various causes that it was not deemed expedient to commence building the superstructure this season. Another reason was the danger of embarrassing the contractor by entering the market against him in the purchase of stone, the supply of which was very limited. When the contractor fairly began his work it was pushed with vigor, 12 cribs being sunk in less than twelve weeks.

In my project of April 10, last, I stated that this supplementary project "may include extension of the piers yet farther, pier-heads, repairs, and refilling of the old work, and dredging, together with a sand-tight revetment on the pile piers, as the experience of this season's work may indicate."

It seems to me that the piers should be extended 150 feet each, so as to insure 18 feet depth of water when the piers are completed; and to enable a beacon-light to be erected as quickly as possible, this extension should be made at the earliest moment practicable. While making this extension I would recommend that the entrance be also widened 100 feet so as to be 335 feet wide instead of 235 feet.

I would propose to partially close the openings between the outer extremities of the present piers, and the inner ends of the extensions by brush mats about 30 feet wide, and 8 feet deep, including the ballast. This opening, it is thought, will allow of the escape of the extra portion of the wave due to the increased width of entrance, while the mat will prevent the sand from entering the channel through the opening. (See accompanying tracing.)

Should experience show that the height of the mat was not sufficient to accomplish this last object, it could be readily increased at small cost. The entire cost of the mats will not exceed $1,000. The intervals where the mats are placed would be crossed by bridges or elevated walks, costing not over $300. If this plan is adopted, a line of fender piling on each side would be necessary to guide vessels into the present narrow opening. The waling-pieces next to the channel would be of 12 by 18 inch oak timber, protected by two rows of railroad iron T rails, and the whole superstructure of the piling would form a strong flexible truss. The 20 feet of piling next to the present piers would be close piling to prevent the riprap from being washed into the

channel. The cost of this fender piling, 330 feet, would be about $3,300. The total expense due to increasing the width of entrance from 235 feet to 335 feet would not exceed $5,000, or about the cost of extending the piers with 30-foot cribs a distance of 30 feet. The advantages arising from increasing the width of entrance 40 per cent. seem to me greater than those due to 30 feet, more or less, in the length of the piers.

This work is of such a nature that it ought to be all done at the same time, and should be done by contract, except the brush mats, which can be made better by hired labor. The work should be advertised this winter, so that it can begin as soon as the season opens.

The above work would cost about $21,000; the six crib superstructures costing about $16,000; and the mats, elevated walks, and fender-piling, about $5,000. As at the opening of next season there will be available some $29,000, after providing for the above there will be $8,000 available for carrying on by hired labor, as already approved by the Chief of Engineers, the sheet lining of the pile-piers, costing complete $5,500, and the building of the superstructure over the 16 cribs now sunk, costing complete $11,000. This will enable work to be pushed until next year's appropriation becomes available; or, if no appropriation is made next year, the contract work will be completed, and the work that is being done by hired labor can be placed in such condition with the money available as to render the harbor quite useful until Congress shall see fit to appropriate funds to complete the work.

This project for the expenditure of the present appropriation provides, it will be noticed, for an actual extension of the original project for the improvement. But the great fall in prices allows all this work to be done within the amount of the original estimate. The piers have already been extended about 25 feet beyond the original plan, and it is proposed to extend them 150 feet further, widening them 100 feet, and revetting the old pile piers, making these additions to the original project cost about $36,000.

But, even including all of this extra work, the harbor can be completed with the $70,000 still remaining of the original estimate unappropriated.

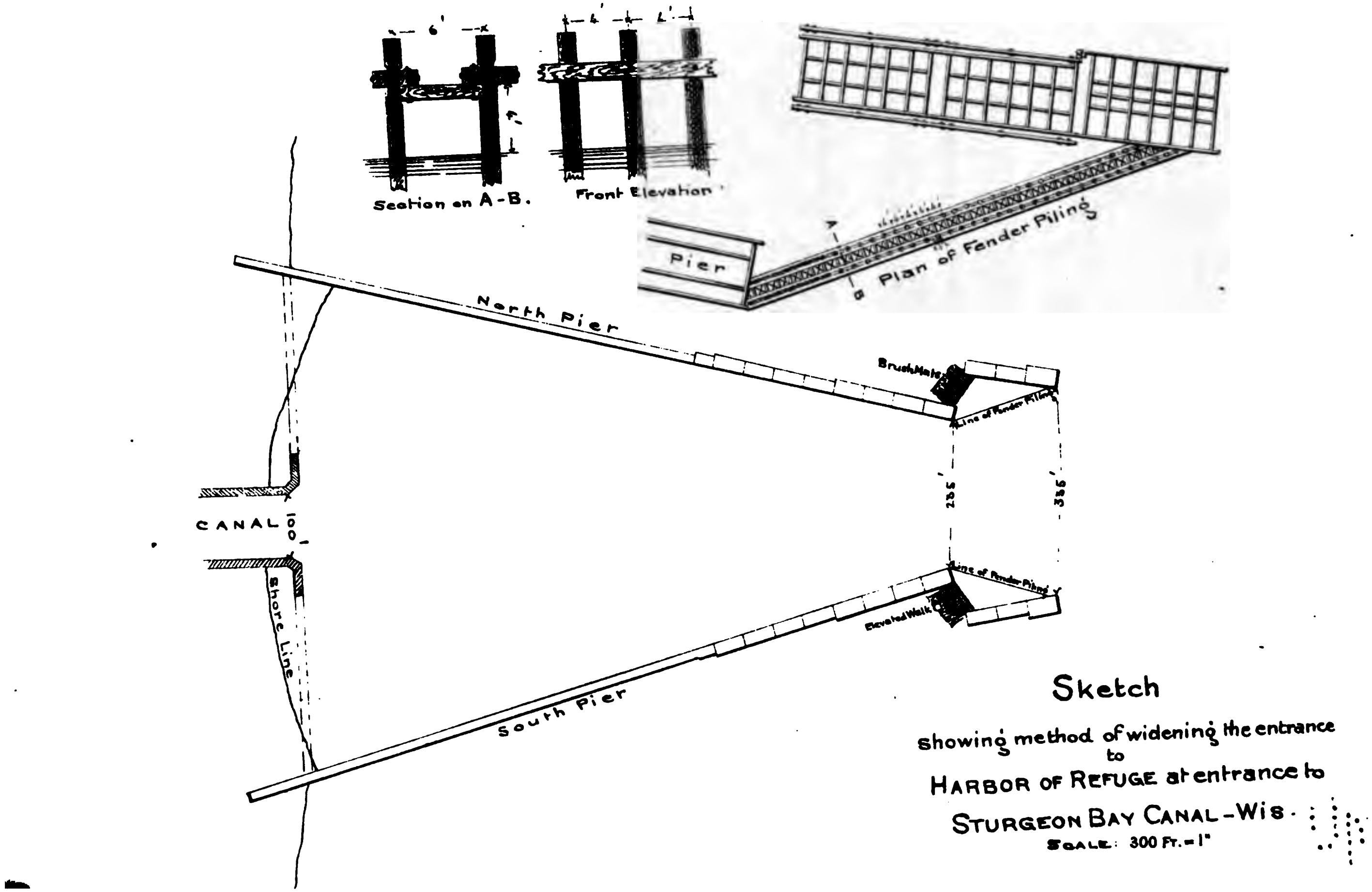
This project was approved by the Chief of Engineers, under date of January 10, 1880.

To accomplish the widening of the entrance from 235 to 335 feet, without producing increased wave action in the inner harbor, the project proposes to place the additional cribs to the right and left of the alignment of the present cribs, leaving an interval of 50 feet at right angles to this alignment between the outer ends of the present extension and the inner ends of the proposed extension. In these intervals brush mats are to be placed, for the protection of the bottom from scour, and to prevent sand from being carried through the intervals into the area between the piers.

The height of the mats above the bottom would be such as to allow the incoming waves to pass over them, thereby preventing any reflex wave action between the piers. The outer ends of the present piers to be connected with the outer ends of the proposed extension by a double row of piles, connected together by struts, tie-rods, and longitudinal timbers, so as to constitute a strong yet flexible construction, against which vessels might collide without injury to themselves, or the pilings. Without this fender-piling a dangerous bight would exist between the present piers and the proposed extension. An elevated walk supported on piles will connect the present piers with the proposed extension, allowing the necessary passage to the pier light.

The outer cribs will be each 30 feet wide, and constitute substantial pier-heads.

The operations contemplated during the present season are the completion of the sand-tight revêtment now in progress by hired labor, and the building and sinking of 6 cribs, and the construction of 330 linear feet of fender piling under contract with Messrs. McDonald & Boalt, and also to "complete, by hired labor and purchase of materials in open market, the superstructures over the 16 crib substructures sunk in the extension of the piers in 1878–'79, provided that the sum of $3,000 may be used in dredging between the piers a channel to the deep water of the



Sketch

showing method of widening the entrance to HARBOR OF REFUGE at entrance to STURGEON BAY CANAL – WIS.

SCALE: 300 FT. = 1"

lake, if the canal company shall protect the canal slopes to such an extent as to render such dredging of permanent value in the judgment of the engineer in charge." (*Extract from my project of June 22, 1880.*)

The completion of the superstructure over the pier extension, with a dredging between the piers, is the work contemplated during the season of 1881-'82.

In the following money statement, the sum of $35,515.49, appears as available at this date. Of this amount fully $20,000 is covered by the contract now in process of execution, and by the work of sheet-pile-lining, also going on at present by hired labor. Within the next three months $25,000 will probably be expended; leaving only about $10,000, as actually available, nearly all of which will be expended during the current year.

Money statement.

July 1, 1879, amount available	$53,319 24	
Received from sale of fuel to officers	62 00	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$63,381 24
July 1, 1880, amount expended during fiscal year, less $546.61 outstanding July 1, 1879		27,865 75
July 1, 1880, amount available		35,515 49
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		40,000 00

Abstract of proposals opened February 23, 1880, by Maj. Henry M. Robert, Corps of Engineers, U. S. A., for improving harbor of refuge at entrance of Sturgeon Bay Canal.

Materials and labor.	O. B. Green, Chicago, Ill.	Knapp & Gillen, Racine, Wis.	Green Bay Dredge and Pile-Driver Company.	Truman & Cooper, Manitowoc, Wis.*	MacDonald & Boalt, Ahnepee, Wis.	A. Hart, Green Bay, Wis.†
	Rate.	Rate.	Rate.	Rate.	Rate.	Rate.
Pine timber, framed, 33,000 linear feet	$0 32	$0 25	$0 24½	$0 22	$0 22½	$0 19$\frac{9}{10}$
Oak timber, framed, 11,800 feet, b. m	30 00	25 00	55 00	40 00	35 00	28 00
Pine plank, laid, 19,000 feet, b. m	17 00	18 00	12 00	11 00	10 00	11 50
Piles, driven, 10,200 linear feet	16	17	15	15	16	14
Drift bolts, 46,600 pounds	06	05½	06	05½	05½	04$\frac{8}{10}$
Screw bolts and tie rods, 35,000 pounds	07	06½	06$\frac{47}{100}$	07	06	05$\frac{7}{10}$
Spikes, 1,200 pounds	07	06¼	06$\frac{4}{10}$	08	06	05$\frac{7}{10}$
Stone, 1,120 cords	4 50	5 00	4 00	3 80	3 75	3 59¾
Total approximate value of proposals	22,731 00	20,634 00	19,591 80	18,268 00	18,013 50	16,469 30

* Thrown out for informality, the bonds not having the signatures of the proposed sureties.
† Thrown out for informality, the bonds not having seals nor the proper number of witnesses to the signatures.
Contract awarded to McDonald & Boalt.

Abstract of contracts at Sturgeon Bay, Harbor of Refuge, Wisconsin, during the fiscal year ending June 30, 1880.

Name of contractor and residence.	Contract for—	Remarks.
Truman & Schroeder, Manitowoc, Wis	Pier extension	Closed October 29, 1879.
McDonald & Boalt, Ahnepee, Wis	do	Work in progress.

List of materials and labor used at Sturgeon Bay Harbor, Wisconsin, under contract with Truman & Schroeder.

Articles.	Contract price.	Quantities and values. 16 cribs, 8 on each pier.	Superstructure.	Wrecked crib No. 3, N. pier, replaced.	Totals.
Pine, 12″ x 18″ .... linear feet..	$0 30	1, 620	....	100	1, 720
Pine, 12″ x 12″ .... do....	20½	57, 708	3, 442	2,294	64, 144
Oak, 12″ x 12″ .... feet, b. m..	25 00	21, 216	....	....	21, 216
Plank, 3″ x 12″ .... do.....	8 00	....	....	1,250	1, 250
Piles, furnished .... linear feet..	08	5, 360	....	180	5, 540
Piles, driving .... each..	2 50	179	....	6	185
Stone, filling .... cords..	4 00	1, 637. 38	258. 02	64.02	1, 969. 42
Drift bolts, 1⅛″ square .... pounds..	02¾	75, 774. 7	4, 741. 5	4,101.5	84, 617. 7
Screw-bolts, N. & W .... do.....	04	9, 429. 84	142. 8	285.06	9, 858. 24
Chain and fittings .... do.....	04½	2, 516. 2	....	....	2, 516. 2
Spike, 9″, wrought .... do.....	03½	450	....	....	450
Labor, extra on 12 cribs	....	$197 65	....	....	$197 65
Total amounts	....	$23, 100 00	$1,873 79	$563 46	$25,537 25

C C 9.

IMPROVEMENT OF AHNEPEE HARBOR, WISCONSIN.

Amount appropriated and allotted, to and including 1875	$80, 000
Revised estimate of 1875 (Report of Chief of Engineers, 1876, II, 359)	95, 000
Total estimated cost	175, 000
Amount appropriated and allotted	110, 000
Amount to be appropriated	65, 000
Amount that can be profitably expended in fiscal year 1881–'82	30, 000

The operations of dredging and rock removal were resumed in October, 1879, by the United States dredge and hired labor. During the fiscal year there were removed 5,521 cubic yards of sand from between piers, and 4,795 cubic yards of rock (scow measurement) from the areas previously drilled and blasted.

The citizens of Ahnepee, appreciating the necessity of connecting the channel below the bridge, in progress by the United States, with the deep water above the bridge, raised by subscription an amount necessary to drill, blast, and dredge the connecting channel. This work was successfully completed, and has resulted in relieving the crowded condition of the lower harbor, by transferring above the bridge the landing of a large number of wood and tie vessels. Previous to the completion of this channel, the operations of the government have been hampered and delayed by the crowded condition of the harbor, in and adjacent to the area covered by the operations of drilling, blasting, and dredging. The general operations of rock removal at this harbor were in the immediate charge of Assistant L. Y. Schermerhorn, to whose report I would refer for details. The necessity of obtaining an increased depth of water between the piers, to facilitate the work being carried on, rendered necessary a sand-tight lining along the 620 linear feet of pile pier on the south side of the entrance. This work was commenced in May last, under the immediate charge of Mr. C. Crosman, and successfully completed June 20.

The operations contemplated during the present season are the resumption of drilling and blasting, and removal of rock by United States dredge and hired labor. It is proposed to utilize a large part of the rock removed for crib-filling at Two Rivers and elsewhere.

A continuation of drilling, blasting, and dredging by hired labor is contemplated during the fiscal year 1881–'82, together with such repairs as may be required on the piers.

Money statement.

July 1, 1879, amount available	$8,513 01	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$15,513 01
July 1, 1880, amount expended during fiscal year		5,806 46
July 1, 1880, amount available		9,706 55
Amount (estimated) required for completion of exist'ng project		65,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		30,000 00

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

JANUARY 2, 1880.

SIR: I have the honor of submitting the following report of operations at Ahnepee, Wis., during the fiscal year 1879–'80. The project for the expenditure of available funds contemplated "the removal, by the United States dredge and hired labor, of the rock now lying broken up in the bed of the river, together with such further drilling and blasting as might be possible from the application of available funds, after setting aside a sufficient part for the work of dredging." The project for operations at Two Rivers proposed the building and sinking of cribs by hired labor, and it was proposed to obtain the stone for filling these cribs from the rock excavation at Ahnepee. Arrangements were made with Mr. George O. Spear to furnish a tug, stone-scows, and all accessories required for towing the stone from Ahnepee to Two Rivers, at the rate of $3 per cord.

The United States dredge was detained at Two Rivers nearly a month beyond the time expected, and consequently did not reach Ahnepee until the middle of October. This was at a time when the wheat and railroad-tie shipments were at a maximum, and frequently as many as 16 vessels were lying at and adjacent to the docks near the inner ends of the piers. The very low stage of water and the limited depth at the inner entrance caused the frequent grounding of loaded vessels between the south and the citizens' pier; at such times entrance to or exit from the harbor was completely cut off. This crowded condition of the harbor, together with the insufficient depth at the inner entrance, operated unfavorably on the rock excavation by delaying the progress of the work and consequently increasing its cost. Attempts were made to increase the depth by dredging, but the open character of the pile piers prevented success. This difficulty and its subsequent remedy are discussed in the latter part of this report.

The United States dredge began the removal of the broken rock October 23, and continued until November 23. During this interval 4,795 cubic yards (scow measurement) were handled, of which amount 1,482 cubic yards were removed from Ahnepee and applied elsewhere for crib-filling and riprap, and the remainder, 3,313 cubic yards, cast over and yet remaining to be removed. The general depth of water over the area of operations was only about 2 feet, and hence this work of casting over became necessary to obtain sufficient depth for maneuvering the scows and dredge. The rock intended for crib-filling was placed by the dredge directly on the stone-scows, care being taken to discard rock too finely broken, or containing much sand and mud. The stone was generally well adapted for crib-filling.

The scows were from 90 to 112 feet long, 24 feet wide, and having an ultimate capacity of from 40 to 50 cords each. The amount of rock carried by the scows was determined by their displacement, allowing a cord of stone to weigh 13,000 pounds. On account of the limited depth of water between the piers, the scows could not be loaded to more than three-fourths of their full capacity.

The months of October and November were unusually stormy, and since it was impracticable to send the scows out except during fine weather, but a comparatively small amount of stone was removed from Ahnepee. Still enough was accomplished to

establish the practicability of economically applying the excavated rock to crib-filling at adjacent harbors.

The dredging was not pushed far enough to determine certainly whether the blasting had been effectual to the full depth of 12 feet below low-water. At a depth of about 9 feet from the water surface a disintegrated seam of rock occurs (this has been described in previous reports). Above this stratum the rock is irregular in character and stratified in quite thin laminæ; below this stratum it is denser and more uniform in character, and entirely unstratified. The dredge was always able to easily carry the excavation down to the above-mentioned seam, but below it little rock was removed. The holes were all drilled from 7 to 9 feet below this seam, and about 90 per cent. of the explosive for each hole was placed below the plane of this seam. I believe that the rock has been fractured to the full depth, but not displaced below the seam to any considerable extent. If a face could once be obtained at a lower level, I believe that the rock would be found broken and removable to the intended bottom. When the dredging has advanced further it will be possible to determine this point more certainly.

The operations of drilling and blasting on the part of the United States were not resumed during the season of 1879. The project for 1879-'80 recognized the desirability of testing the economy and practicability of using the excavated rock for crib-filling at adjacent harbors, and the limited amount of funds available made it necessary to set aside the larger part of such funds for the work of dredging. This, taken in connection with the unavoidable delay in beginning the rock excavation and the crowded condition of the harbor in the fall of the year, rendered it impracticable to renew the operations of drilling and blasting.

DETAILS OF ROCK REMOVAL.

Rock handled by United States dredge (scow measurement) 4,461 cubic yards, of which there were sent to—

	Cubic yards.
Two Rivers	985
Manitowoc	339
Sturgeon Bay	158
	1,482
Quantity cast over	3,313
Total quantity dredged	4,795

The dredge was engaged 32.9 working days, of which 10.7 days were spent in repairs and changes and 22.2 days actually occupied in handling rock. This gives for the quantity of rock handled per working day 145.7 cubic yards; per day worked, 216 cubic yards. The cost of the rock excavation, including the towing of dredge from Two Rivers to Ahnepee and the expenses of laying up for the season, was as follows:

Repairs	$568 13
Expenses	1,202 76
Aggregate	1,770 89

or at a cost of 36.93 cents per cubic yard scow measurement, or 64¼ cents per cubic yard prism measurement. In the foregoing comparison between scow and prism or place measurement, 1 cubic yard in place is taken as equal to 1.75 cubic yards in scow.

The rapidly increasing commercial requirements of Ahnepee demand such work as will give an early increase in the depth of water along the south pier, and seems to indorse the propriety of the modification of the hitherto proposed order of work as set forth in the project approved by the Board of Engineers December 15, 1875. The south pile pier allows the passage of the sand through it, which quickly obliterated the channel as deepened by dredging. To prevent this a modification of the project was proposed, which would permit such work as was necessary to render the pile pier sand-tight. This work was commenced May 11 and closed June 17. During this time the south pile pier (620 linear feet) was revetted with a sand-tight sheet-pile lining. The details of construction and methods of operation were similar to those adopted at Two Rivers, Wis. Previous to the placing of the sheet piling, a trench was excavated by the dredge close alongside of the pile pier, removing as far as possible drift-wood and stone. Afterwards the sheet piling was placed, by aid of the water-jet, in close contact, rendering the pier sand-tight. This will enable a channel to be maintained along the south pier, greatly facilitating the local commerce of the harbor and the government operations thereat.

The project for the removal of the rock ends at the highway bridge. The shallow water over the rock continues for a distance of about 250 feet above the bridge, and

then deepens to about 8 feet. The citizens of Ahnepee, recognizing the value of a connection between the deeper water above the bridge and the upper end of the channel (in progress by the United States), raised by private subscription $1,800. With this amount a connecting channel, 200 feet in length, 40 feet in width, and about 10 feet deep, was drilled and blasted in the fall. Early in the season of 1880, the United States dredge removed the broken rock. The work was carried on under my general supervision, and with the tools and plant previously used on work below the bridge. All expenses, including labor, explosives, supplies, and repairs, were paid by the citizens' subscription.

The amount expended was as follows:

Drilling and blasting	$1,444 14
Dredging	359 64
	1,803 78

With this expenditure about 1,000 cubic yards (prism measurement) of rock were removed, giving a channel 35 feet wide and 7 feet deep, and connecting the work in progress by the United States with the deep water above the bridge. This will permit the wood and tie vessels to load above the bridge, relieving the lower harbor of a large number of vessels and removing one of the most serious obstacles to the progress of the government work.

Very respectfully, your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

Statement showing the details of work of the United States dredge at Ahnepee Harbor, Wisconsin, in 1879.

Material.	Time.		Quantity dredged.		
	Working.	Worked.	Total dredged.	Per working day.	Per day worked.
	Days.	*Days.*	*Cub. yards.*	*Cub. yards.*	*Cub. yards.*
Sand	5.1	3.4	2,691	527.6	791.5
Rock	32.9	22.2	4,795	145.7	216
Total	38	25.6	7,486		

Material.	Cost.		Cost per cubic yard.		
	Expenses.	Repairs.	Expenses.	Repairs.	Total.
Sand	$189 31	$89 42	$0 07.03	$0 03.32	$0 10.35
Rock	1,202 76	568 13	25.08	11.85	36.93
Total	1,392 07	657 55			

Began work October 13. Closed work November 25. Working days 10 hours each.

NOTE.—Thirteen and six-tenths per cent. of total time worked was applied to the removal of sand; and 86$\frac{4}{10}$ per cent. of total time worked was applied to removal of rock. The total expenses and repairs have been divided between sand and rock according to percentages of time worked on each.

Statement showing cost of revetting the south pile pier at Ahnepee Harbor, Wisconsin, the revetment consisting of a double row of 3-inch pine plank 18 feet long, secured by two wales to the superstructure of the pier.

Length of work.	Cost.				
	Materials.	Superintendence and labor.	Dredging.	Total.	Per linear foot.
620 linear feet	$1,470 94	$923 07	$340 00	$2,734 01	$4 41

COMMERCIAL STATISTICS.

Name of harbor, Ahnepee, Wisconsin.
Collection district, Milwaukee, Wis.
Nearest light-house, Twin River Point, Wisconsin.

Arrivals and departures of vessels during year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	94	28, 200	1, 692	94	28, 200	4, 692
Sailing vessels	248	31, 496	2, 232	248	31, 496	2, 232
Total	342	59, 696	3, 924	342	59, 696	3, 924

Exports during year ending December 31, 1879.

Bark ....cords..	802	Peas..........bushels..	450
Barley ....bushels..	20, 000	Posts ....number..	123, 000
Butter..........tons..	100	Rye ....bushels..	1, 000
Eggs..........dozens..	5, 000	Railroad ties ....number..	470, 000
General merchandise..........tons..	1, 000	Shingles ....do....	1, 000, 000
Leather..........sides..	2, 000	Wheat ....bushels..	150, 000
Lumber..........feet, b. m..	318, 000	Wood ....cords..	5, 000

Imports during the year ending December 31, 1879.

Beef..........barrels..	100	Pork ....barrels..	300
Flour ....do....	2, 000	Salt ....do....	2, 500
General merchandise..........tons..	3, 500	Sugar ....do....	1, 000
Lumber ....feet, b. m..	76, 000	Whisky ....do....	150

The above information was obtained from Chas. J. Barnes and Samuel Perry.

C C 10.

IMPROVEMENT OF TWO RIVERS HARBOR, WISCONSIN.

Estimated cost for extending the piers to the 18-foot curve, with dredging between the piers	$265, 588 80
Appropriated since	160, 000 00
Amount to be appropriated	105, 588 80
Amount which can be profitably expended during the fiscal year 1881–'82..	50, 000 00

The operations during the past fiscal year have consisted in the completion of the sand-tight lining to the pile-piers. In this work 320 linear

feet of double and 446 linear feet of single sheathing was placed on the north pier. In connection with this work 153 linear feet of pile revetment was capped with timber. The sand-tight lining to the pile-piers consisted of oak plank placed as sheet-piling and secured by wales and bolts to the pile-piers. The methods of construction and manner of sinking the sheet-piling by means of the water-jet have been previously described in last year's report on this harbor (Report of Chief of Engineers, 1879, pages 1512–1514). It is believed that this method of rendering pile-piers sand-tight will overcome the objection previously existing and due to their permeable character. By aid of the water-jet the piles are placed in intimate contact, insuring an unbroken continuity not otherwise to be obtained in sheet-piling, and thereby rendering the piers sand-tight, and obviating the filling of the channel by sand carried through the herefore permeable pile-piers.

For the extension of the piers seven cribs were built by hired labor and the purchase of material in open market. One crib was sunk in extension of the north pier. For the crib-filling it was proposed to utilize the rock removed from Ahnepee, but on account of the advanced state of the season, and the unusually stormy fall, only 208 cords of stone were delivered. The stone remaining after sinking one crib was used in preparing beds for the cribs to be built and sunk by hired labor during the present season. A temporary dock for the storage of stone and to facilitate the construction of the cribs was also built in the inner harbor.

During the year the United States dredge removed from the channel between the piers 49,801 cubic yards of sand and clay. Of this amount 29,056 cubic yards were removed during the season of 1879, and 20,245 cubic yards during the months of May and June, 1880. [For details of this work see the tabulated statement under Port Washington Harbor.]

This amount of dredging has opened a channel between the piers about 1,200 feet in length, 75 feet in width, and with a depth of 11 feet. The present limited extension of the piers renders the preservation of this channel problematical; but upon the completion of the extension in progress and proposed during the present season, it is expected that this difficulty will disappear, and that the harbor can be opened and maintained for its local commerce.

A survey has been made of this harbor and its vicinity, and the results are now being plotted.

The operations for the present season will comprise the sinking of the six cribs already built and the construction and sinking of three additional cribs, all in extension of the north pier, the work to be continued by hired labor and the purchase of material in open market, utilizing for crib-filling the stone derived from the rock-excavation at Ahnepee; also the building and sinking of 11 cribs more or less, by contract, in extension of the south pier. The foregoing work will extend the piers to the 14-foot curve.

The work proposed during the fiscal year 1881–'82 is the further extension of the piers and dredging between, with such repairs and refilling of the piers as may be necessary.

Money statement.

July 1, 1879, amount available	$22,027 80	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$42,027 80
July 1, 1880, amount expended during fiscal year		14,567 42
July 1, 1880, amount available		27,460 38

Amount (estimated) required for completion of existing project $105,588 80
Amount that can be profitably expended in fiscal year ending June 30, 1882.. 50,000 00

Statement showing the cost of sheathing the harbor piers at Two Rivers, Wis.

Nature of work.	Length of work.	Total cost.	Cost per linear foot.	Average cost per linear foot.
	Linear feet.			
Double sheathing:				
South pier (1878)	427½	$2,510 27	$5 87	$5 05 8/10
North pier (1879)	630	2,838 77	4 50 6/10	
Single sheathing, without wales:				
South pier (1878)	514	690 32	1 34 3/10	1 32 4/10
North pier (1879)	273	351 82	1 29	
Single sheathing:				
South pier (1878)	48	162 73	3 39	3 39
Single sheathing, including capping 2 rows of piles, without wales:				
North pier (1879)	170	421 22	2 47 8/10	2 47 8/10
Total		6,975 13		

COMMERCIAL STATISTICS.

Name of harbor, Two Rivers, Wis.
Collection district, Milwaukee, Wis.
Nearest light-house, Twin River Point, Wisconsin.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	210	105,000	3,000	210	105,000	3,000
Sailing vessels	200	19,000	750	200	19,000	750
Total	410	124,000	3,750	410	124,000	3,750

Exports during the year ending December 31, 1879.

Cattle and sheep	pounds..	1,008,000
Chairs	dozen..	15,000
Doors, blinds, and sash	number..	50,000
Fish	packages..	1,000
Fresh fish	pounds..	600,000
Flour	barrels..	6,360
Furniture	pieces..	15,000
Grain	bushels..	18,000
General merchandise	tons..	4,000
Hair	pounds..	100,000
Lath	number..	100,000
Lumber	feet, b. m..	200,000
Railroad ties	number..	2,000
Slabs	cords..	2,000
Sundries	pounds..	40,000
Wood	cords..	2,000
Wooden ware	dozen..	120,000
Leather	pounds..	800,000

Imports during the year ending December 31, 1879.

Bark	cords..	1,500
General merchandise	tons..	10,000
Grain	bushels..	8,000
Hides, dry	number..	18,000
Hides, green	do....	14,000
Iron wire	tons..	500
Lumber, hard	feet, b. m..	700,000
Lumber, pine	do....	1,200,000
Salt	barrels..	2,000
Shingles	M..	500
White wood (pine and birch)	cords..	500

The above information was obtained from the Two Rivers Manufacturing Company, Badger State Manufacturing Company, and agent Milwaukee, Lake Shore and Western Railroad Company.

C C II.

IMPROVEMENT OF MANITOWOC HARBOR, WISCONSIN.

Original and subsequent estimates to extend piers to 18-foot curve, with dredging between piers	$248,182 54
Appropriated since	239,820 00
Amount to be appropriated	8,362 54
Amount which can be profitably expended in fiscal year 1881-'82	8,362 54

The operations for the past fiscal year have consisted in building, by hired labor and purchase of material in open market, superstructures over 6 cribs (sunk by contract in 1878-'79), at an expense of $2,817.10. The superstructures were about half filled with stone. With this work the piers have a present extension of about 1,620 feet on the north, and 1,550 feet on the south side. In November a steamer ran into the outer end of the south pier, displacing about 40 linear feet for a distance of 18 inches. The injury was immediately repaired at an expense of $44.15.

In the month of April injury occurred to the north pier from similar causes.

Accidents of this character have been frequent, and when occurring during the absence of the inspector were not discovered until a subsequent visit of the inspector was made.

The necessity of prompt information concerning such accidents led to the following correspondence. On April 22 last I wrote as follows to the Chief of Engineers:

SIR: I have the honor to submit that at many harbor works there are no official representatives of the government resident during the winter season, except the light-keepers. Accidents are of frequent occurrence, especially those due to vessels running into the pier, damaging it, and the officer in charge is not notified until in the spring an employé of his makes an official visit to the work.

Two recent cases on harbors in my charge are in point. In one the light-house burned and the pier received some damage from fire, of which the only information received by me was a statement in the newspapers that the whole harbor (!) had been destroyed by fire. In the other case a blow from a passing vessel put out the light, and broke 4 timbers in the pier. This was only discovered by me accidentally three weeks after its occurrence.

I would respectfully recommend that the Light-House Board be requested to instruct all light-keepers to report to the engineer officer in charge any damage to the harbor works occurring at any time at their several stations, together with the cause of the same. Such a duty would probably not entail more than two or three reports in a year from any light-keeper, and would afford the engineer officer the information necessary to enable him to provide for the immediate repair of damages.

In reply the following communication from the engineer secretary of the Light-House Board, dated April 28, 1880, was received by the Chief of Engineers:

SIR: The Board has received a copy of a letter dated April 22, from Maj. H. M. Robert, U. S. A., asking that the light-keepers be instructed to report to engineer officers in charge of harbor works any damage that may occur to piers, &c., on the lakes; this letter being forwarded on April 27 with your favorable indorsement. In reply I have to say that the officers in charge of these lights have been instructed by the Board to require reports from light-keepers of any accidents within their knowledge. This information will be sent to you on its receipt at this office.

The operations for the present season will consist in the extension of the piers by building and sinking four cribs, more or, less by contract; and the completion of the stone filling and planking, by hired labor and purchase of material in open market, of the six superstructures built last season.

During the fiscal year 1881-'82 it is proposed to continue the pier extension to the 18-foot curve as contemplated in the original projects and estimates; and to do such dredging and make such repairs as may be necessary. The unusually low stage of water during the past two years has caused a rapid increase in the bar formation at the entrance to the piers, the exact extent of which cannot be stated until surveys now in progress are completed.

Money statement.

July 1, 1879, amount available	$8,763 65	
Received by sale of fuel to officers	62 00	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$15,825 65
July 1, 1880, amount expended during fiscal year		4,123 14
July 1, 1880, amount available		11,702 51
Amount (estimated) required for completion of existing project		8,362 54
Amount that can be profitably expended in fiscal year ending June 30, 1882		8,362 54

COMMERCIAL STATISTICS.

Name of harbor, Manitowoc, Wisconsin.
Collection district, Milwaukee, Wis.
Nearest light-house (on harbor pier), Manitowoc, Wis.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	416	267,729	11,350	414	266,795	11,297
Sailing vessels	467	33,481	1,559	472	34,870	1,591
Total	883	301,210	12,909	886	301,665	12,888

Exports during the year ending December 31, 1879.

Brick	number	818,000	Posts	number	23,100
Broom-handles	do	18,500	Railroad ties	do	44,050
Butter	pounds	525,379	Rags	sacks	3,028
Eggs	dozen	195,360	Shingles	number	498,000
Feed	tons	1,171	Wheat	bushels	132,125
Flour	barrels	38,179	Wood	cords	18,300
Hay	tons	3,139	Cattle	head	1,884
Pease	barrels	16,965			

Imports during the year ending December 31, 1879.

Apples.................barrels..	2,710	Lumber..........feet (b. m)..	3,669,000
Coal.......................tons..	1,058	Salt.................barrels..	4,435
Corn..................bushels..	4,400	Plaster.................tons..	260
Fruit....................boxes..	1,484	Shingles...............number..	6,518,000
General merchandise......tons..	25,000	Slabs...................cords..	1,115
Lath..................number..	254,000	Oil.................barrels..	755
Lead..................pounds..	9,750	Vegetables..............boxes	1,090

The above information was obtained from George B. Burnet, deputy collector.

MEMORIAL TO CONGRESS IN RELATION TO THE HARBOR AT MANITOWOC, WISCONSIN.

To the honorable the Senate and House of Representatives of the United States of America in Congress assembled:

The memorial of the board of aldermen of the city of Manitowoc, Wis., respectfully represents—

That the Manitowoc Harbor, by reason of its location at the commercial center of a large manufacturing and agricultural district, is of great importance to local commerce, and also the commerce of Lake Michigan, as it affords the only harbor of refuge on the west shore of Lake Michigan north of Milwaukee for the fleet of vessels trading between Chicago, Milwaukee, and northern and eastern ports.

That the United States Government has expended a large amount of money in building harbor-piers, extending the same into the lake far enough to obtain an average depth of 15¼ feet of water.

That the harbor cannot be entered by vessels drawing that depth of water for the reason that between the harbor piers sand and other *débris* has accumulated which it will be necessary to have removed by dredging.

That the city of Manitowoc has at all times materially and liberally assisted in the improvement of the said harbor. In 1866 the city built a dredge and scows at an expense of about $20,000, and allowed the contractor doing government work the use of the same at a nominal rent, by reason of which the government was able to have the work of excavating 117,913 cubic yards done at the rate of 20 cents per cubic yard, while the same kind of work was paid for at other ports along the lake shore at the rate of 40 cents per cubic yard, being a net saving to the government in one year on the cost of excavating the sum of $23,582.60.

That the city has, at its own expense, done dredging at various times as follows:

	Cubic yards.
In 1868	47,070
In 1869	20,000
In 1870	19,000
In 1871	18,000
In 1872	41,490
In 1873	33,665
In 1874	32,700

That the city has also built about one mile of docks at an expense of about $50,000.

That the city of Manitowoc is ready and willing to expend the necessary money to dredge the river proper to make the same navigable for large vessels, in case the general government will appropriate the necessary money to do the work of dredging between the harbor piers, but that the city of Manitowoc is unable to do all of said work at its own expense.

Your memorialists ask leave to call the attention of your honorable body to the following extracts from the reports of United States Engineers in charge of the improvements on the western shore of Lake Michigan north of Milwaukee, Wis.

Annual report of the Chief of Engineers for 1876, Appendix W, on page 54, reference is made to the fact of the building of the dredge heretofore referred to, and after giving a history of Manitowoc Harbor to the year 1875, on page 58, Maj. D. C. Houston says:

"To comment at length upon the advantages derived by the city of Manitowoc, and the district of which it is the commercial center, or the benefit derived through this improvement by the lake marine generally, would be superfluous; for what has already been shown respecting the increase of trade at this point by this brief history must be conclusive evidence as to its importance as regards Manitowoc, and a simple statement of the fact that as many as 150 vessels of all descriptions sought shelter in this harbor

during the prevalence of one protracted storm will attest to its importance as a harbor of refuge."

Annual report United States Engineers, 1877, Appendix Y, page 863, speaking of the importance of an early completion of the harbor at Manitowoc, Maj. H. M. Robert says:

"The entire through commerce of the lakes bound from Buffalo to Milwaukee and Chicago is destitute of shelter on the east shore of this lake after leaving South Manitou Island Harbor, with the exception of that afforded by the harbor at Grand Haven, situated 150 miles to the southward and 50 miles directly out of the regular course. As the prevailing winds are westerly, masters of vessels usually seek the west shore for the purpose of finding still water, striking it about Twin River Point, 10 miles northeast of Manitowoc Harbor. For a similar purpose the through commerce bound from Chicago and Milwaukee to Buffalo ordinarily hugs the west shore as far north as Twin River Point. After leaving Milwaukee, this harbor, 75 miles to the northward, affords the best shelter from violent storms, and from thence northward no harbor of refuge is available nearer than Bailey's Harbor, or North Bay, 70 to 75 miles distant. In addition, therefore, to the great benefit conferred upon local traffic, this harbor should be completed as soon as possible for the refuge it affords to the general commerce of the lakes and vessels plying to and from Green Bay and the ports on the western shore of Lake Michigan; and this importance should insure its maintenance forever. The extent to which it is sought in time of peril is an indication of the estimate placed upon its advantages, 150 vessels having sought shelter therein during a single storm. Were the piers extended to sufficient depth of water to admit of heavily laden vessels entering it during severe gales, its value would be greatly enhanced."

Annual Report of Chief of Engineers, 1879, page 1160, Appendix Z, Maj. H. M. Robert says:

"The recommendation contained in my last annual report in reference to the importance of the early completion of this excellent harbor is respectfully renewed. As will be seen by reference to that report, the position of Manitowoc Harbor gives it a more than local importance, and makes its completion a matter in which the whole commerce of the lake is interested." (See Report Chief of Engineers, 1877, page 863.)

Your memorialists further desire to call the attention of your honorable body to the fact that Manitowoc, by reason of the natural excellence of its harbor and its location with reference to communication between the wheat-fields of Minnesota and the markets of the East, has been fixed upon as the eastern terminus on the western shore of Lake Michigan of a transportation route in which several different railway companies are interested, extending from Minneapolis to Manitowoc, thence across Lake Michigan by steamer to the city of Ludington, about 62 miles east of Manitowoc, connecting at that point with the Flint and Pere Marquette Railway.

That this route is a much shorter route between Minnesota and the East, than any now existing or proposed.

That Manitowoc Harbor is open for navigation during most of the year, ice-blockades seldom occurring, and is well fitted for the uses proposed.

In consideration of the facts hereinbefore set forth, your memorialists ask your honorable body to appropriate the sum of $20,000 to dredge that part of the Manitowoc Harbor between the harbor piers, said sum to be expended under the direction of the United States Engineers in charge of said improvement.

And your memorialists will ever pray.

Adopted February 2, 1880.

THE BOARD OF ALDERMEN
of the City of Manitowoc, Wis.

C C 12.

IMPROVEMENT OF SHEBOYGAN HARBOR, WISCONSIN.

The work at this harbor was completed within the amount estimated.

During the past fiscal year 62 linear feet of old superstructure on the north pier was removed and rebuilt by hired labor and purchase of material in open market; and 6,955 cubic yards of sand were removed from the channel between the piers by the United States dredge. (For details of this dredging see the tabulated statement under Port Washington Harbor.)

In June, 1880, an arrangement was made with the city of Sheboygan to do the necessary dredging. If this agreement had been carried out it would have accomplished the work at a reasonable price to an extent

sufficient for the immediate requirements of the harbor. However, the city sold the dredge to private parties, who preferred to work inside the shore line. After the removal of only 213.27 cubic yards of material, the United States dredge was set at work for a short time in order to open a channel through the worst part of the bar obstructing the entrance; 455 cubic yards were removed. The work will be continued for about two weeks, when the dredge will be required at Ahnepee Harbor.

During the present season dredging will be done on the outer bar and in the channel between the piers.

A detailed survey of this harbor is now in progress; upon its completion a supplementary report will be made covering the proposed work for the fiscal year 1881–'82.

Money statement.

July 1, 1879, amount available	$5,062 95	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$12,062 95
July 1, 1880, amount expended during fiscal year		2,755 85
July 1, 1880, amount available		9,307 10
Amount that can be profitably expended in fiscal year ending June 30, 1882, for repairs and dredging		5,000 00

COMMERCIAL STATISTICS.

Name of harbor, Sheboygan, Wis.
Collection district, Milwaukee, Wis.
Nearest light-house, Sheboygan, Wis.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	686	466,881	17,115	686	486,841	17,100
Sailing vessels	351	23,638	1,141	357	22,464	1,125
	1,037	590,519	18,256	1,043	509,305	18,225

Exports during the year ending December 31, 1879.

Barley	bushels	1,495,205	Horses	number	15
Beans	do	1,005	Leather	tons	647
Brick	number	935,500	Land plaster	do	645
Butter	pounds	141,360	Lime	barrels	15,732
Cattle	number	1,460	Peas	bushels	55,051
Castings	tons	118	Pork-barrels	number	16,408
Chairs	number	435,000	Potatoes	bushels	245
Cheese	tons	2,432	Rye	do	2,000
Eggs	pounds	53,520	Sheep	number	460
Feed	tons	400	Wheat	bushels	338,870
Fish	pounds	255,790	Wooden ware	tons	363
Flour	barrels	7,374	Wool	pounds	51,110
Grass seed	tons	276	General merchandise	tons	6,183
Hogs	number	218			

Imports during the year ending December 31, 1879.

Bark ....cords..	6,235	Posts ....number..	9,768
Cement ....tons..	400	Salt ....barrels..	9,500
Coal ....do...	8,700	Shingles ....number..	5,082,000
Corn ....bushels..	10,000	Shingle-bolts ....cords..	1,500
Hides ....number..	80,000	Slabs ....do...	275
Lath....................do....	1,183,000	Stucco.................barrels..	100
Lumber ....feet, b. m..	12,479,554	Wood ....cords..	1,300
Pickets ....number..	49,650	General merchandise....tons..	2,779
Plaster-rock ....tons..	2,415		

The above information was obtained from Messrs. E. P. Ewer, J. L. Mallory, and the editor of the Times.

C C 13.

IMPROVEMENT OF PORT WASHINGTON HARBOR, WISCONSIN.

Original estimate for extending the piers to the 14-foot curve, with the excavation of a (west) river basin to a depth of 13 feet....	$154,527 17
Additional estimate due to lowering plane of reference $2\frac{2}{10}$ feet	27,000 00
Total present estimate..	181,527 17
Appropriated	120,500 00
Amount to be appropriated..	61,027 17
Amount that can be profitably expended in fiscal year 1881-'82..........	40,000 00

The project for this harbor provides for extending the piers to 14 feet depth of water and dredging to 13 feet depth in the basins. The additional inside basin approved of by the Chief of Engineers, June 7, 1877, added no more to the cost than was saved by the fall in prices since the original estimate was made. But it was found that the plane of reference used at this harbor was entirely too high, and, as stated in my last annual report, I had to lower it $2\frac{2}{10}$ feet to bring it to the level of five-tenths of a foot above the low-water of July and August, 1847, which I have adopted now for all the harbors under my charge. During the last summer the water was frequently only five-tenths of a foot above our new datum. This change in the plane of reference will add 30,000 cubic yards of excavation at 30 cents, costing $9,000, and six cribs at $2,500, costing $15,000, and $3,000 for superintendence and contingencies, or a total addition of $27,000 to the original estimate, in or to carry out the piers to 14 feet depth of water measured from new plane of reference.

Operations for the past fiscal year have consisted in the removal by the United States dredge and hired labor of 3,410 cubic yards of sand from the channel between the piers, and the building and sinking of two cribs in extension of the north pier, under contract with Messrs. Knapp & Gillen; also the partial refilling of superstructure in the south pier. In April the river made a breach through the south embankment of the west basin. The work of repairing this injury being held as not properly belonging to government, it was made by and at the cost of the village of Port Washington.

During the present season it is proposed to build and sink 11 cribs more or less in extension of the piers, and to make such repairs and do such dredging as the available funds will permit.

During the fiscal year 1881-'82, it is contemplated to continue the pier extension, with such dredging between the piers as may be necessary to open the harbor for the local requirements of commerce.

Money statement.

July 1, 1879, amount available	$4,300 00	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$24,300 00
July 1, 1880, amount expended during fiscal year, less $1,811.70 outstanding July 1, 1879		4,296 22
July 1, 1880, amount available		20,003 78
Amount (estimated) required for completion of existing project		61,027 17
Amount that can be profitably expended in fiscal year ending June 30, 1882		40,000 00

Statement showing details of work of the United States dredge during the season of 1879 at the harbors of Two Rivers, Wis., Sheboygan, Wis., and Port Washington, Wis.

Harbor.	Time.		Quantity dredged.			Cost of work.			Cost per cubic yard.			
	Working.	Worked.	Total.	Per working-day.	Per day worked.	Expenses.	Repairs.	Preservation.	Expenses.	Repairs.	Preservation.	Total.
	Days	*Days*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*				*Cts.*	*Cts.*	*Cts.*	*Cts.*
Port Washington	17.0	9.1	5,210	$306\frac{5}{10}$	$572\frac{5}{10}$	$594 43	$71 08	$200	11.41	1.36	3.84	*16.61
Sheboygan	15.0	11.5	6,955	$463\frac{6}{10}$	605	456 69	61 60	......	6.57	0.88	.....	7.45
Two Rivers	57.0	41.3	29,056	$509\frac{7}{10}$	$703\frac{5}{10}$	1,942 94	333 28	......	6.69	1.14	.....	7.83
Totals and av'ge cost.	89.0	62.9	41,221	463	$655\frac{3}{10}$	2,994 06	465 96	200	7.26	1.13	0.49	8.88

Average cost per cubic yard, 8.88 cents; working-days, 10 hours each.

* This apparent increase in cost above the cost per yard last year is due to the fact that all the expenses for preservation during the year were charged to Port Washington Harbor account on a very small total expenditure.

Abstract of contracts at Port Washington Harbor, Wisconsin, during the fiscal year ending June 30, 1880.

Name of contractor and residence.	Contract for—	Remarks.
Knapp & Gillen, of Racine, Wis	Pier extension	Closed August 30, 1879.

List of materials and labor used at Port Washington Harbor, Wisconsin, under contract with Knapp & Gillen, for two crib substructures, each 50 by 20 by 12½ feet.

	Price.	Quantities.	Amount.
Pine timber, 12 by 18 ... linear feet	$0 28½	200	$57 00
Pine timber, 12 by 12 ... do	21	6,228	1,316 28
Pine plank laid ... per M feet	13 00	4,608	59 90
Drift-bolts ... pounds	$02\frac{9}{10}$	8,241.9	239 02
Screw-bolts, N. and W ... do	04	1,175	47 00
Spikes ... do	04	324	12 96
Stone filling ... cords	6 75	228	1,539 00
Total for two crib substructures			3,271 16

COMMERCIAL STATISTICS.

Name of harbor, Port Washington, Wis.
Collection district, Milwaukee, Wis.
Nearest light-house, Port Washington, Wis.

Arrivals and departures of vessels during the year ending December 31, 1879.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	398	121,400	7,378	398	121,400	7,378
Sailing vessels	143	8,775	472	143	8,775	472
Total	541	130,175	7,850	541	130,175	7,850

Exports during the year ending December 31, 1879.

Beer	barrels	1,520
Brick	number	326,000
Butter	tons	55
Castings	do	840
Cheese	pounds	178,000
Cattle	number	535
Eggs	barrels	950
Fish	packages	2,150
Flour	barrels	8,185
General merchandise	tons	100
Hay	do	390
Hides	number	110
Leather	sides	8,262
Lime	barrels	140,000
Malt	bushels	52,000
Oats	do	5,500
Plows	number	250
Pork-barrels	do	4,325
Smut-machines	do	107
Wheat	bushels	83,480
Stone	cords	600
Wood	do	510
Wool	pounds	13,160

Imports during the year ending December 31, 1879.

Barley	bushels	8,800
Coal	tons	864
Coke	do	210
Corn	bushels	3,710
General merchandise	tons	430
Land plaster	do	355
Lath	number	1,000,000
Lumber	feet, b. m.	5,200,000
Pig-iron	tons	870
Reapers	number	74
Seeders	do	16
Shingles	do	6,000,000
Tan-bark	cords	378

The above information was obtained from the Merchants and Manufacturers' Association.

C C 14.

SURVEY FOR HARBOR OF REFUGE AT ENTRANCE TO PORTAGE LAKE AND LAKE SUPERIOR SHIP-CANAL.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 15, 1879.

SIR: I have the honor to submit the following report on the survey for harbor of refuge at entrance to Portage Lake and Lake Superior Ship-Canal, called for by the river and harbor appropriation act approved March 3, 1879, and made in August last by Mr. L. Y. Schermerhorn, my assistant, whose report and map are appended hereto.

This canal seems to be used mainly by steamers, sailing vessels preferring to go around Keweenaw Point. During 1878 only 6 sailing vessels passed through the canal, while 259 steamers and 106 tugs passed through it in the same time. The entrance to the canal is 250 feet wide, with only 12 or 13 feet of water at the end of the piers.

There is nothing, in my judgment, to justify the construction of an outer harbor of refuge at this point. There is plenty of harbor room inside, and the only difficulty experienced is in entering the canal. The placing of a breakwater to cover the head of the canal would do nearly as much harm as good, because, while it might make the water smoother, it would cut off the straight approach to the canal, and thus increase the difficulty of making the entrance. The vessel captains, I understand, do not think that such an "improvement" would be any improvement at all.

The real need at this point is increased facility for entering the canal. This, I think, can be most readily and economically attained by adopting something like the plan which I suggested in my report of May 18, 1876, on Capt. Frank Barr's letter on the lake harbor works, as a remedy for the evil of narrow entrances to these harbors. The piers at the Portage Lake Canal entrance should be extended about 330 feet, so as to reach 18 feet water, costing about $70,000; and the extra expense of widening, at the same time, the entrance, from 250 feet to 400 feet, would not exceed $5,500.

The widening of the entrance by this method will not, I think, increase the disturbance in the channel, while it doubles the ease with which vessels can enter the canal.

The plan proposed is to build the pier extensions not on the lines of the present piers, but parallel to and 75 feet outside of them, thus increasing the width 150 feet. The openings between the heads of the present piers and the inner ends of the extentions, averaging 50 feet, would prevent any material increase in the disturbance being caused by the increased width of the entrance. These intervals should be partially closed with brush mats, say 8 feet thick, which would prevent the scouring from the increased velocity of the waves at these points, and would also prevent the outside sand from being washed into the channel. The cost of these mats would be about $1,000. An inexpensive elevated walk over the intervals would connect the present piers with the extensions. To guide vessels from the new entrance into the present narrower channel, there would be required a series of fender-piles strongly connected, of which about 20 feet of the inner portion would have to be solid piling, so as to prevent the washing into the channel of the riprap. The cost of this fender-work would be about $9 per linear foot; or in all, say, $4,500; which, with the cost of the mats ($1,000),

would make the $5,500 above mentioned as the extra expense of widening the entrance, above the cost of simply extending the piers.

This improvement, which, in my judgment, is the only one required at the entrance to "Portage Lake and Lake Superior Ship-Canal," it will be noticed, is nothing but an improvement to the head of the canal already constructed, to *aid* which the United States has already donated 400,000 acres of land. (See act of March 3, 1865, Statutes at Large, vol. 13, page 519, and act of July 3, 1866, Statutes at Large, vol. 14, page 81.)

The act donating this land to the State of Michigan states that it is to *aid* "in constructing and completing a harbor and ship-canal," &c., and the improvement here discussed is for the purpose of "*completing* [said] harbor and ship-canal." The canal company have stopped their piers where, at low-water, the depth is not over 12 feet, whereas the United States finds it necessary, at less important points, to extend its piers to 18 feet water.

I do not think the entrance to the canal can be said to be completed until the piers are extended to a depth of water equal to that which is considered necessary at the harbors constructed directly by the United States. If this were done a great deal of the difficulty experienced in entering the canal would disappear. It is not to be expected that a vessel can be easily steered in rough water when its keel almost touches bottom. This lack of depth of water at the head of the canal is, in my judgment, the greatest difficulty at this point, and the remedy is *for the canal company to complete the work*, to aid which the United States donated 400,000 acres of land.

The extending the piers 330 feet farther, so as to insure 18 feet of water, would place this entrance on a footing with the entrances to our other lake harbors. Its present width of 250 feet is the same as that of the entrance to the "harbor of refuge at entrance of Sturgeon Bay Canal, Wisconsin," now being built by the United States, and in fact is exceeded by only one of all the harbors in my charge, namely, Menomonee, where the width is due to peculiar circumstances. But, as shown above, an increased width of 150 feet, if desired, could be attained while extending the piers at an increased cost of 8 per cent.

This canal is in the collection district of Superior. The nearest port of entry is Marquette, Mich. There is a light at the entrance—Portage Lake Ship-Canal light.

During the season of 1878, 259 steamers, 106 tugs, and 6 sailing vessels passed through the canal; an aggregate tonnage of 228,689 tons.

Very respectfully, your obedient servant,

HENRY M. ROBERT,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

NOVEMBER 9, 1879.

SIR: I have the honor of submitting the following report on the survey for the "harbor of refuge at the entrance to Portage Lake and Lake Superior Ship-Canal."

This canal is about 2 miles in length, and connects the northern end of Portage Lake with Lake Superior, obtaining a water transit across the southern end of Keweenaw Point, and permitting the commerce of the south shore to move between Duluth and Sault Ste. Marie uninterrupted by Keweenaw Point. This route saves about 38 miles, and the dangers and difficulties of an outside passage, and places Houghton and Hancock—the principal ports of the copper district of Lake Superior—in direct communication with the south shore lines.

By act of Congress, March 3, 1865, 200,000 acres of land were donated by the United States to the State of Michigan for the purpose of aiding the State in constructing and completing a "breakwater, and harbor, and ship-canal" upon the line of its present location; the canal to be 100 feet wide, and with a depth of water not less than 13 feet; the same to be completed within 2 years from the passage of the act. "Whenever the State shall be fully reimbursed for all advances made, * * * the State to be allowed to tax for the use of the canal only such tolls as shall be sufficient to pay all necessary expenses for the care, charge, and repairs of the same."

By act of Congress, July 3, 1866, an additional grant of 200,000 acres was made, and further providing that the land-grants shall inure to the use and benefit of the Portage Lake and Lake Superior Ship-Canal Company. Three additional years were granted for its completion.

By subsequent acts of Congress the time for its completion was extended five times. It was completed December 1, 1873.

In its location and general surroundings it resembles the Sturgeon Bay and Lake Michigan Ship-Canal. The sides of the canal are protected by a cheap and inefficient sheet-pile revetment, which is now badly out of repair. The piers at its entrance to Lake Superior are well built and in good condition. The toll-rates charged by the company are shown by the appended schedule. The following statement of tolls collected was furnished by James Pryor, esq., canal superintendent:

Season of 1874	$8,822 58
Season of 1875	5,756 48
Season of 1876	3,883 69
Season of 1877	4,436 60
Season of 1878	6,060 82
Total for 5 years	28,960 17

During the season of 1878 the following commerce passed through the canal:

	Tons.
259 steamers with aggregate of	218,146
106 tugs with aggregate of	9,458
6 sail-vessels	1,085
Aggregate	228,689

The canal company are obliged, annually, to resort to dredging to maintain a depth of 13 feet, and the general cost of maintenance probably equals the revenue derived from tolls.

Omitting any discussion of the propriety of the United States undertaking work which seems to properly belong to the canal company, I will proceed to the details of a plan verbally indicated by yourself.

The present width at the entrance between the piers is 250 feet, and the distance from the entrance to the canal proper is 950 feet. In rough weather or in a heavy sea, vessels are obliged to make the entrance under full headway, otherwise they steer badly and are in danger of missing it.

The short distance between the entrance and the canal makes it difficult to bring a vessel so thoroughly under control as to make the entrance to the narrower width of the canal safe or easy. Hence any work would improve the present entrance which safely increased the width between the piers, and at the same time gave increased facilities for safely entering the canal. The plan suggested proposes to accomplish this by extending the present piers for a distance of 330 feet, and to a depth of 18 feet of water. The extension to be parallel to the existing piers, but with the width increased to 400 feet. In the intervals between the outer ends of the present piers and the inner ends of the proposed extension, brush mats would be placed. These mats would protect the bottom from scour and prevent sand from being carried into the harbor through the intervals between the piers. The height of the mats would be such as to allow the incoming waves to pass over them, thereby preventing any reflex action. An elevated walk supported on piles would bridge the interval between the piers.

The outer ends of the present piers to be connected with the proposed extension by a double row of piles 6 feet apart between the rows, with the piles in each row 4 feet apart. The piles to be connected by struts, tie-rods, and longitudinal timbers, so as to constitute a substantial fender, against which vessels might safely collide and be guided into the narrower entrance at present existing.

The following estimate is based on timber cribs filled with stone and heavily rip-rapped. The 14 cribs in extension of the piers to be 30 feet wide and from 20 to 28 feet in height:

ESTIMATE.

480 linear feet fender piling, 270 piles, at $6	$1,620	
1,600 linear feet 12″ × 12″ pine timber, at 25 cents	400	
9,000 feet B. M. 12″ × 18″ oak timber, at $20	180	
16,000 pounds screw-bolts and tie-rods, at 8 cents	1,280	
480 linear feet of iron protection to outer wall, at $1	480	
Add 10 per cent	396	
		$4,356
Brush mats between ends of existing and proposed piers:		
150 cords brush mats, at $6	900	
Add 10 per cent	90	
		990
14 cribs 50′ × 30′ in extension of piers:		
108,000 linear feet 12″ × 12″ pine timber, at 25 cents	27,000	
160,000 pounds 1⅛″ drift-bolts, at 6 cents	9,600	
5,100 cords stone, at $5	25,500	
80,000 feet B. M. plank, at $12	960	
Add 10 per cent	6,306	
		69,366
Aggregate		74,712

If all the cribs less than 24 feet in height were reduced to a width of 24 feet, the foregoing estimate would be changed as follows:

8 cribs in extension of the piers, 50′ by 30′; 6 cribs in extension of the piers, 50′ by 24′; 480 lineal feet double fender piling.

Total of items required for foregoing	$64,540
Add 10 per cent	6,454
Aggregate	70,994

or a reduction from the previous estimate of $3,718. The piers exposed to the heavy seas and ice of Lake Superior demand the most substantial work; hence I do not consider the above saving commensurate with the increased stability of the wider cribs.

The plan suggested would require to be completed in two seasons, and the work could not be commenced until appropriations had been made which would be sufficient to complete it. After work had been commenced, the entrance would be far from safe in rough weather until the cribs were all placed and the guiding piles driven.

Very respectfully, your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

RATE OF TOLLS ESTABLISHED BY THE STATE BOARD OF CONTROL FOR THE LAKE SUPERIOR SHIP-CANAL, RAILWAY AND IRON COMPANY, UNDER THE PROVISIONS OF "AN ACT TO PROVIDE FOR DETERMINING AND REGULATING THE TOLLS," APPROVED APRIL 25, 1873.

AUDITOR-GENERAL'S OFFICE,
Lansing, Mich., July 6, 1875.

Resolved, That the following rate of tolls shall be levied, collected, and paid for the use of the Portage Lake and Lake Superior Ship-Canal: Two cents per ton of the vessel's enrolled tonnage, each way, for vessels of every size and capacity, using the canal for each trip: *Provided*, That no toll or other charge shall be collected upon tug-boats, provided they are not employed in carrying freight or passengers, or upon vessels of the United States engaged in the public service.

RALPH ELY,
Secretary Board and Auditor-General.

AUDITOR-GENERAL'S OFFICE,
Lansing, Mich., July 12, 1878.

Resolved, That from and after this date (May 17, 1878) the same tolls that are now collected by the Portage Lake and River Improvement Company upon freight, merchandise, and passengers passing through their improvements, be charged and collected by the Lake Superior Ship-Canal, Railway, and Iron Company upon all freight, merchandise, and passengers passing through their canal to and from any points on

Portage Lake, Torch Lake, or the waters thereof, except on passengers to and from ports in the State of Michigan above said canal, who shall be exempt from tolls.

No tolls shall be collected on through passengers and freights.

RALPH ELY,
Secretary Board of Control.

C C 15.

EXAMINATION OF BAYFIELD HARBOR, WISCONSIN.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 13, 1879.

SIR: I have the honor to report that, in compliance with your instructions, an examination was made in August last of the harbor at Bayfield, Wis., called for by the river and harbor appropriation act approved March 3, 1879.

Herewith I transmit the report and map of my assistant, Mr. L. Y. Schermerhorn.

This harbor was reported on by me November 30, 1876, when I could not find anything requiring improvement. I have the same report to make now.

The harbor is in the collection district of Duluth. The nearest port of entry is Duluth, Minn. The nearest light-house is La Pointe light, 5½ miles distant.

No commercial statistics have been collected, as no improvement is recommended.

Very respectfully, your obedient servant,

HENRY M. ROBERT,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

AHNEPEE, WIS., *November* 8, 1879.

SIR: I have the honor of submitting the following report on the examination of Bayfield Harbor, Lake Superior, Wis.:

The village and harbor of Bayfield is situated on the south shore of Lake Superior, and directly west of the Apostle Islands.

The commerce of the harbor is local and limited. It lies directly on the route between the south shore ports, and the steamers regularly touch at the Bayfield dock.

The shore in the vicinity is bold and rocky, and the deep water extends very close to the shore.

The steamboat dock is about 250 feet in length, and extends to about 12 feet depth of water. By increasing its length about 100 feet a depth of 18 feet of water would be obtained. The harbor is under the lee of the Apostle Islands, and is at all times easy and safe of access, and does not require any artificial protection.

Bayfield and its vicinity is the great natural harbor of refuge of Lake Superior, and in its deep water and closely-clustering islands nature seems to have left nothing for the engineer to do.

Very respectfully, your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

C C 16.

EXAMINATION OF ASHLAND HARBOR, WISCONSIN.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 13, 1879.

SIR: I have the honor to submit the following report on the examination of Ashland Harbor, Wis., called for by the river and harbor appropriation act approved March 3, 1879.

The examination was made in August last by Assistant Engineer L. Y. Schermerhorn, whose report and map of the same are herewith submitted.

I do not see that the harbor needs any improvement. Three years ago I examined this same question, and could not then find any necessity for any improvement by the United States.

If in the future it should be found that the cut through the spit continues to increase to any extent, it might be advisable to consider the question of the expediency of trying to stop this increase.

This harbor is located in the collection district of Duluth. The nearest port of entry is Duluth, Minn.

No commercial statistics have been obtained, as no improvement is recommended. The nearest light is La Pointe light.

Very respectfully, your obedient servant,

HENRY M. ROBERT,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

AHNEPEE, WIS., *November* 8, 1879.

SIR: I have the honor of submitting the following report on the examination of Ashland harbor, Lake Superior, Wis.:

Ashland is directly south of the Apostle Islands and at the southern extremity of Chequamegon Bay, and is the present northern terminus of the Wisconsin Central Railroad.

The harbor is land-locked on all sides except the north, while even from this last direction it receives almost thorough protection from Chequamegon Spit and the Apostle Islands.

The commerce of the harbor is transacted over bridge piers and docks which extend to a depth of 12 feet of water. The present dock of the Wisconsin Central Railroad Company is about 1,600 feet in length.

The southern end of Chequamegon Bay is very shallow, and the transmitted map, reduced from the United States Lake Survey, seems to show a tendency to shoaling over the entire south end of the bay, which may in time require an extension of the docks by their owners. The present depth of water obtained seems sufficient for the demands of commerce.

At the northern end of Chequamegon Bay is Chequamegon Point, which is a narrow sand spit starting from the east shore and extending in a northwest direction about 7 miles. The spit is generally less than 200 feet in width, except at its northwestern extremity, and has an elevation varying from 2 to 10 feet above the surface of the lake. In its general direction it is exactly on the prolongation of the main shore east of the point. The spit sustains a growth of dwarf pine and underbrush, except in two places, which are shown on the accompanying map. An examination of the trees established the fact that they are at least 50 years old. The bearing of the above statement will be seen in what follows:

In 1873, during a severe northerly gale, a breach was made by the sea through the spit near its eastern end. This breach now has a length of about one-half mile. Since its first formation it has alternately increased and diminished in length, but the present opening seems to be the maximum which it has ever attained, and at the time of this examination seemed to be increasing.

This breach was made through one of the two points above mentioned as having been previously destitute of tree growth; I infer that these two parts of the spit have been denuded of their vegetable growth by former breaches of the sea, the subsequent action of the waves restoring the spit at some time during the last fifty years. This leads to the inference that the operations of nature will again restore the present breach to its former condition. The spit bears evidence of comparatively recent origin, and it seems fair to infer that the causes which operated in its formation will continue for its perpetuation. The spit serves as a natural protection to Chequamegon Bay, and should be preserved if the continued action of the waves seems to point to its ultimate destruction. The question should be re-examined in the near future, and if the breach continues increasing in length, the present exposed ends of the breach should be protected against further erosion by brush and stone revetment.

It is stated that the spit near its eastern end has, in past times, been artificially opened for the purpose of moving rafts of timber from the lake into the bay.

The spit should have been retained as a government reservation, and by that means protected against artificial injury.

I have devoted this space to the consideration of Chequamegon Point in connection with the examination made, since it seemed the only point to which the attention of the government was required in connection with Ashland Harbor.

Very respectfully, your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

C C 17.

EXAMINATION OF MANISTIQUE RIVER, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 20, 1879.

SIR: Herewith I have the honor to submit a report and map of an examination of Manistique River, Michigan, called for by the river and harbor appropriation act approved March 3, 1879, under the title "Morristique River." The examination was made in November last by my assistant, Mr. L. Y. Schermerhorn.

The sum of $6,000 would be sufficient for the necessary dredging; and is all that the general commercial interests involved seem to me to justify.

Very respectfully, your obedient servant,

HENRY M. ROBERT,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

DECEMBER 20, 1879.

SIR: I have the honor to submit the following report on the examination of Manistique Harbor, Michigan.

In May, 1873, Mr. J. Pierpont, United States assistant engineer, under direction of Maj. D. C. Houston, Corps of Engineers, U. S. A., made a detailed survey of, and report on, this harbor. (See Report of Chief of Engineers, 1873, page 254.)

The estimated cost of its improvement was $290,000, and the conclusion derived from the survey was "there are no facts tending to show that the general commerce of the country will be benefited by the improvement of this harbor."

No appropriations have ever been made for its improvement.

Since the date of the above report, the occurrence of the following facts, while not justifying a radical change in the foregoing conclusion, might modify its tenor.

The commercial interests of Manistique are, as they were at the time of the previous report, merged in the lumber trade. The Chicago Lumbering Company, owning large and valuable areas of timber land on the Manistique and its tributaries, have rebuilt and enlarged their former mill near the river's mouth, so that it has a capacity of about 30,000,000 feet, board measure, per annum. A steam-mill, owned by other parties, has been recently built further up the river. It has a capacity of about 10,000,000 feet, board measure, per annum. The lumber interests have invested about $1,000,000 of capital, of which $500,000 has been applied to the mills and their immediate surroundings.

The Manistique and its tributaries drain over 1,400 square miles, and good judges estimate the amount of fine timber, profitably attainable on this watershed, at 1,500,000,000 feet, board measure.

The Chicago Lumbering Company have displayed a rare and commendable energy in their efforts to improve the entrance to the river by the construction of piers on

each side of the natural entrance, extending into the lake to about the 14-foot curve. The piers are 40 feet wide, parallel, and 350 feet apart, with a length on each side of the entrance of about 1,600 feet. The piers were constructed by sinking cribs of round timber at intervals of 50 feet apart, filling the cribs with stone and edgings; the intervals between the several cribs being filled with slabs and edgings only. As the work settled into the sand, additions were made to the height until settlement ceased. At the time of this examination the piers were in good alignment and at a height of about 6 feet above the water surface. The settlement of the slabs and edgings has been very uniform, and shows no tendency to tilt towards the channel. Since the construction of the piers the shore line has advanced 400 feet on the eastern and 200 feet on the western side. Upon the outside the sand has banked well against the piers, and gives no indication of passing through into the harbor.

This season the Chicago Lumbering Company employed a dredge in partially removing the sand from between the piers and in dredging out slips in the inner harbor. At the time of this examination the dredging was very evident, giving a channel of about 10 feet in depth along the east pier.

Manistique River during freshets has a very large discharge, and previous to the construction of the piers, the flood currents cut their way through the bar at the river's mouth, and gave for a short time a deep entrance to the inner harbor. Mr. W. B. Colwell, manager for the Chicago Lumbering Company, estimates the high-freshet current at 6 miles per hour. This is undoubtedly overestimated and excessive, but an apprehension of these currents led the company to place their piers 350 feet apart, fearing that a less width would unduly obstruct the flood discharge and result in excessive scour. Since the construction of the piers the freshet discharge has been unusually small and the scouring, between the piers, very limited. The large watershed of the Manistique seems to justify large enough flood discharge to produce strong scouring effects between the piers. This, taken in connection with the previous statements as to their comparatively sand-tight character, seems to justify the assumption that if the sand was once removed from between the piers that thereafter a sufficient depth would be maintained by natural causes.

The Chicago Lumbering Company have already expended $20,000 on their improvements of the harbor. Of this amount about $15,000 have been applied to the construction of the piers and dredging between them. The slabs and edgings used in the pier extension were without value to the company for any other purpose, and do not form an item in the foregoing statement of expenditures.

The removal of about 20,000 cubic yards of sand from between the piers, in connection with the dredging already done by the company, would give a channel 150 feet in width, with a depth of about 12 feet. This amount of work would cost about $5,000. An appropriation of this amount would place the harbor under the conservation of the United States, and while testing the value of the work already done by private enterprise, would give an opportunity for more detailed observation and examination. Should experience demonstrate that the work already done is of value, further appropriations might be judiciously applied in extending the existing piers, for a short distance, with substantial crib-work.

The northern shore of Lake Michigan from Point Detour to the Straits of Mackinaw, a distance of almost 120 miles, presents a shore line unbroken by a single harbor except the present entrance to Manistique. Ignoring the local interests of Ministique Harbor I believe that the general interests of commerce would justify the comparatively small expenditure required to test the efficiency of the work already done by private enterprise, and determine the advisability of further appropriations.

The sawdust and other mill refuse is now thrown directly into the river. This quickly settles to the bottom, and renders inefficient the general improvement. If any appropriation is made the mill-owners should be required to desist from allowing this refuse to pass into the river.

Manistique is located in the collection district of Superior.

The nearest port of entry is Grand Haven, Mich.

The nearest light-house is Poverty Island light, 35 miles distant from Manistique.

It was impracticable to collect commercial statistics at the time of this examination; they will be transmitted as soon as obtained.*

Very respectfully, your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

* See report on Manistique Harbor, Mich., for the fiscal year ending June 30, 1880.

APPENDIX D D.

IMPROVEMENT OF HARBORS OF MILWAUKEE, RACINE, KENOSHA, AND WAUKEGAN, LAKE MICHIGAN—IMPROVEMENT OF FOX AND WISCONSIN RIVERS.

REPORT OF MAJOR D. C. HOUSTON, CORPS OF ENGINEERS, BVT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., July 3, 1880.

GENERAL: I have the honor to transmit herewith annual reports for the works in my charge for the fiscal year ending June 30, 1880.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

D D 1.

IMPROVEMENT OF MILWAUKEE HARBOR, WISCONSIN.

CONDITION OF THE WORK JUNE 30, 1880.

The general condition of the work is good.

A channel has been dredged, 100 feet wide and 18 feet deep at mean lake-level, from the river inside the piers to the lake. The total amount appropriated for this harbor by the government up to date is $315,987.45, of which $50,000 was expended on the old river mouth, now closed up.

The natural channel at the outlet of the Milwaukee River previous to its improvement was never more than from 50 to 75 feet wide. Quite a large volume of water was discharged during the spring freshets which would produce at such times a depth of 9 feet of water, but the effect of this was only temporary. As soon as the scouring effect of the current of the freshet was reduced the bar would form, over which there was not more than from 3½ to 4 feet of water. The improvement of the natural outlet was undertaken some time in the year 1843 by sinking cribs on the natural bed of the lake, out to the line of 10 feet of water, and a channel was dredged between the piers. In order to maintain a channel of 9 feet in depth a continuous use of the dredge was necessary.

The project for the improvement of this harbor by cutting across the point which overlapped the mouth of the river at a distance of 3,000 feet north of the natural outlet was adopted in 1852, and operations were fairly commenced in 1854. This project contemplated the maintenance

of a channel 12 feet deep and of navigable width. The project was modified in 1867 with a view to providing a channel 200 feet wide and 16 feet deep. Soon after the artificial channel (now known as the "Straight Cut") became available to navigation, the natural outlet was closed by shore accretions.

PROGRESS DURING FISCAL YEAR ENDING JUNE 30, 1880.

W. H. Hearding, assistant engineer, reports progress as follows:

By act of Congress of date March 3, 1879, the sum of $7,500 was appropriated for the improvement of this harbor. This sum became available on the 1st of August, and in response to advertisement, proposals were received for dredging between the harbor piers, and a contract was made with Messrs. Starke, Smith & Co. to do the work for 19¾ cents per cubic yard, that firm being the lowest bidder.

The weather during the month of October and early part of November was unfavorable for dredging in exposed positions. On the 15th of the latter month the work was suspended for the season.

The number of cubic yards of material excavated was 25,452, which gave an improved channel of 100 feet in width and 18 feet in depth, at mean lake-level, for the whole distance from that depth of water in the lake to the river channel inside the harbor. The plat of soundings taken during the early part of May, 1880, shows that no change of importance was effected in the depth of water in the channel during the winter through the influence of storms or other causes; the banks on either side of the dredged section remaining well defined, except at one or two points, where they were slightly degraded by the wave action. During last month the contractors completed their contract by excavating 4,548 cubic yards of material, making a total of 30,000 cubic yards.

PROPOSED APPLICATION OF FUNDS AVAILABLE FOR EXPENDITURE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

It is proposed to widen the channel between the piers by dredging, and to repair the inner ends of the piers where they connect with private docks.

PROPOSED APPLICATION OF FUNDS ASKED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

In my annual report for 1879 I estimated the average annual expense of maintaining this harbor by pier extension and dredging at $10,000. It is not possible to say whether any pier extension will be necessary during the year ending June 30, 1882, but it may be, and as this is one of the most important harbors on the lakes, having a large and increasing commerce, the sum of $10,000 at least should be made available for its maintenance. The act of June 14, 1880, directs a survey of the bayou south of the harbor, with a view to its improvement. This work will require a much larger amount.

The letter of March 17, 1879, calling for annual reports, asks for specific information on certain points, numbered from 1 to 10. These are given below in the same order.

The present plan is the maintenance of the channel, and piers for its protection.

The channel will require periodical dredging, and the piers will have to be extended from time to time to keep pace with the gradual shoaling caused by accretions due to storms and currents in the lake and river. The timber superstructure will also have to be renewed from time to time, or replaced by stone or iron. Repairs, rendered necessary by collisions and storms, will also be required. I estimate that an average yearly expenditure of $10,000 will suffice for the maintenance

of this harbor. This is necessarily conjectural, as it may be modified by unforeseen demands and change of plans.

Amount that can profitably be expended during next fiscal year, $10,000.

The nearest collection district is Milwaukee, Wis. The nearest port of entry is Milwaukee, Wis.

Amount of revenue collected at the nearest port of entry during the last fiscal year was $171,847.67.

The general commerce of the lakes, as well as the local commerce, is benefited by this harbor.

The total arrivals and departures at this port during the last fiscal year is reported by the United States collector as follows:

	Number.	Tonnage.
Arrivals, steamers	2,474	2,073,788
Arrivals, sail	3,076	517,261
Total arrivals	5,550	2,591,049
Departures, steamers	2,500	2,099,962
Departures, sail	3,086	521,405
Total departures	5,586	2,621,367

Money statement.

July 1, 1879, amount available	$10,016 91	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$20,016 91
July 1, 1880, amount expended during fiscal year	7,755 29	
July 1, 1880, outstanding liabilities	1,400 90	
		9,156 19
July 1, 1880, amount available		10,860 72
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		10,000 00

Abstract of proposals received and opened August 28, 1879, for "improving harbor at Milwaukee, Wis."

DREDGING.

Number and name.	Residence.	30,000 cubic yards, more or less.	Total cost under each bid.
		Per cub. yd.	
1. Stark, Smith & Co	Milwaukee, Wis	$0 19¾	$5,925
2. F. M. Knapp	Racine, Wis	21	6,300

Contract made September 1, 1879, with Stark, Smith & Co., for dredging at price given in their proposal above.

D D 2.

IMPROVEMENT OF RACINE HARBOR, WISCONSIN.

CONDITION OF THE WORK JUNE 30, 1880.

The project for the improvement of this harbor was adopted about the year 1843 and modified in 1866. The object in the first instance

was to secure a channel of 12 feet of water. The modification contemplated the maintenance of a channel of entrance of navigable width, and of a depth not less than 15 feet. The condition of the natural channel is graphically described by Mr. A. P. Dutton, who took up residence at Racine in 1841, as shown by the following extract of a letter received from him, and which description is verified by other old residents of the place. He says:

When I came to Racine in 1841, no vessels entered the harbor, for we had no entrance at that time. The mouth of the river would bar up during northeasters so that scows drawing 16 or 18 inches of water could not get in nor out. I have often crossed the mouth without wetting my feet. Now and then the head of water in the river would force a channel 5 or 6 feet deep, and it would so remain for several days until another storm came from the northeast.

In 1842 and 1843 piers were put in and some small vessels entered. In 1844 and 1845 we claimed to have quite a harbor, and larger vessels entered the port. The channel inside might have averaged 100 feet inside the flags, in some places, and in other places not more than 50 or 60 feet running from 7 to 12 feet deep. In the spring of 1848, the first bridge pier was built, and for several years nearly all of the steamers and sail-vessels landed at it on account of the harbor not being accessible for anything but small craft. Year after year the government has extended the piers and dredged the channel, until we can safely say we have a good and safe harbor to enter.

Racine now claims to be the second city in the State of Wisconsin in point of population as it is in manufacturing industries. The capital invested in manufactures is $4,000,000. The value of the articles manufactured is nearly $7,000,000 annually. The employés engaged in the factories are paid annually about $1,200,000.

The total amount which has been appropriated by the government for this harbor up to date is $203,185.

PROGRESS DURING FISCAL YEAR ENDING JUNE 30, 1880.

W. H. Hearding, assistant engineer, reports progress as follows:

At the date of report of June 30, 1879, the dredging machine belonging to the Racine Dredging Company had commenced the work of removing the material deposited in the channel between the harbor piers during the previous winter. This machine was employed thirty-one and three quarter days with the services of tug-boat and scows at the rate of $65 per day. The quantity of material excavated was 13,738 cubic yards, which made the cost of excavation 15.02 cents per yard. The channel provided by this means was 100 feet wide and 15 feet deep for the whole length of the channel between the piers, and out to the depth of 15 feet of water in Lake Michigan.

Under the appropriation by Congress of March 3, 1879, the harbor of Racine received $6,000, which became available on the first day of August, and was applied to building superstructure over the 50 feet by 30 feet crib, sunk in extension of the north pier in 1878, and in building and sinking an additional crib in extension of the same pier. This work was done under the conditions of a contract made with Messrs. Knapp & Gillen, of Racine, of date September 1, 1879, in conformity with the provisions stated in advertisements printed in the daily papers requesting proposals to do this work.

From present indications it is inferred that a portion of the sand drift by the wind will be arrested by the fence, which was built upon the north wall of the north harbor pier in June, 1879, as a deposit is already collecting on the north side of it.

Upon the opening of navigation this year a recurrence of sedimentary deposit was found to have been made in the channel, which prevented the passage of vessels into the harbor when drawing more than 13 feet of water. About 20 per cent. of this deposit was brought down by the river current from its upper reaches.

This estimate was made by observing the proportion of black alluvium which was readily distinguished from the lake sand. As a large amount of wheat was stored in the elevator, which was awaiting shipment by vessels, it was of great importance that the obstruction to the channel should be removed to admit of the wheat being advantageously transported by water carriage. At the earnest solicitation of the merchants of Racine, the balance of funds remaining from the appropriation of March 3, 1879, was applied to dredging in the channel. The services of the Racine dredge were obtained upon the same terms as in 1879, viz, $65 per day of ten hours, for dredge, tug,

and scows. The time worked by the dredge was thirty days. The number of cubic yards excavated was 12,193, the cost being 15.9 cents per yard. By this means a channel 50 feet wide and 15 feet deep has been provided across the bar and between the harbor piers as far as the elevator wharf, and a fair entrance secured for the season of 1880.

PROPOSED APPLICATION OF FUNDS AVAILABLE FOR EXPENDITURE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

It is proposed to expend these funds in extension of the north pier and in necessary dredging between the piers.

PROPOSED APPLICATION OF FUNDS ASKED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

It is proposed to expend these funds in further pier extension and dredging in the channel.

An examination of the harbor last May revealed a shoal beyond the ends of the piers with but 15 feet of water where, three years ago, there was a depth of over 20 feet.

The letter of March 17, 1879, calling for annual reports, asks for specific information on certain points numbered from 1 to 10. These are given below in the same order.

The present plan is the maintenance of the channel and piers for its protection. The channel will require periodical dredging and the piers will have to be extended from time to time to keep pace with the shoaling caused by storms and the currents in the lake and river. The timber superstructure will also have to be renewed from time to time or replaced by stone or iron. Repairs rendered necessary by collisions and storms will also be required. I estimate that an average yearly expenditure of $8,000 will suffice for the maintenance of this harbor. The appropriations have been much less than the estimates, and it has been necessary to expend a considerable sum in dredging. It is probable that the formation of the shoal previously referred to will necessitate the early extension of the piers. The channel between the piers should next season be dredged to 15 feet for its full width. I estimate, therefore, for the next fiscal year the sum of $14,000, and a subsequent annual expenditure of $8,000 for maintenance. The latter estimate is necessarily conjectural, and may be modified by unforeseen demands or changes of plan.

Amount that can profitably be expended during the next fiscal year is $14,000.

Racine is in the collection district of Milwaukee, Wis. The nearest port of entry is Milwaukee, Wis.

The amount of revenue collected at the nearest port of entry during the last fiscal year was $171,847.67.

The general commerce of the lakes, as well as local commerce, is benefited by this harbor.

The total arrivals and departures at Racine during the past fiscal year are as follows:

	No.	Tonnage.
Arrivals of steamers	532	341,095
Arrivals of sail vessels	668	90,986
Total	1,200	432,081
Departure of steamers	532	342,095
Departure of sail vessels	676	92,748
Total	1,208	434,843

Money statement.

July 1, 1879, amount available	$10,165 11	
Amount appropriated by act approved June 14, 1880	6,000 00	
		$16,165 11
July 1, 1880, amount expended during fiscal year	7,220 89	
July 1, 1880, outstanding liabilities	2,090 00	
		9,310 89
July 1, 1880, amount available		6,854 22
Amount (estimated) required for completion of existing project		14,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		14,000 00

Abstract of proposals received and opened August 28, 1879, for "improving harbor at Racine, Wis."

PIER EXTENSION.

Number and name.	Residence.	Pine timber, 71,196 feet, b. m. (per M, b. m.).	3" pine plank, 4,000 feet, b. m. (per M, b. m.).	Iron drift bolts, 8,771 pounds (per pound).	7" spikes, 200 pounds (per pound).	Stone, 258 cords (per cord).	Framing timber, 71,196 ft., b. m. (per M, b. m.).	Total cost of crib under each bid.
1. F. M. Knapp and E. Gillen	Racine, Wis	$13 50	$9 25	$0 3	$0 4	$6 50	$4 00	$3,231 05
2. F. F. Lovell & Co	do	14 00	10 00	3	4¼	6 50	9 00	3,626 13

Contract made September 1, 1879, with Knapp & Gillen for pier extension at prices given in their proposal above.

D D 3.

IMPROVEMENT OF KENOSHA HARBOR, WISCONSIN.

CONDITION OF THE WORK JUNE 30, 1880.

The project for the improvement of this harbor was adopted in 1844, when it was contemplated to provide a channel of 12 feet in depth. The plan was modified in 1867, the object being to afford a channel of entrance of navigable width and of not less than 15 feet in depth. Before improvement was made a sand beach or bar covered the outlet, but at times the water discharged by Pike Creek and Pike River into the basin would acquire a sufficient head to force a narrow channel across the bar, and for a few days a passage was kept open of from 2 to 4 feet in depth, which would admit of small craft entering, but the recurrence of a northeast storm would again bar up the entrance so that pedestrians could walk across the natural outlet dry shod.

The commerce of Kenosha is steadily increasing. The receivers and shippers of merchandise estimate the trade of the past fiscal year to be greater by 25 per cent. than it was during the year previous.

The total amount appropriated by the government for this harbor up to date is $199,307.41.

PROGRESS DURING FISCAL YEAR ENDING JUNE 30, 1880.

Mr. W. H. Hearding, assistant engineer, reports progress as follows:

The appropriation of $5,000 made by Congress on the 3d day of March, 1879, for the improvement of this harbor, became available on the 1st of August. An advertisement was inserted in the daily papers requesting bids for the construction of one crib, 50 feet in length and 24 feet in width, to be placed in extension of the north pier and for the building of superstructure over the two cribs which were sunk in 1878 in extension of that pier.

Messrs. Knapp & Gillen, of Racine, Wis., being the lowest bidders, were awarded the contract, which was duly framed and entered into on the 1st day of September, 1879. The crib was built to a height of 16¼ feet and sunk upon a stone foundation on the 9th day of October, and the superstructure over the two cribs was built up to the required height during the same month. Both the crib and superstructure were well ballasted with stone. During the winter the outer or east end of the crib settled about 18 inches, and the upper timbers of the crib tilted towards the north 9 inches.

The depth of water in the channel between the piers at the opening of navigation this year was 11½ feet. Over the bank or bar in front of the harbor entrance it was 14 feet. The city authorities of Kenosha have dredged a narrow channel midway between the piers to a depth of 14 feet, in order to admit the passage of coal-laden vessels into the basin.

The accretions along this section of the shore of Lake Michigan are extensive, and will continue to necessitate the use of the dredging machine every year to a greater or less extent.

PROPOSED APPLICATION OF FUNDS AVAILABLE FOR EXPENDITURE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

It is proposed to expend these funds in the extension of the north pier.

PROPOSED APPLICATION OF FUNDS ASKED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

It is proposed to expend these funds in extension of the piers, dredging the channel, and needed repairs.

The letter of March 17, 1879, calling for annual reports, asks for specific information on certain points numbered from 1 to 10. These are given below in the same order.

The present plan is the maintenance of the channel and piers for its protection. The channel will require periodical dredging, and the piers will have to be extended from time to time to keep pace with the shoaling caused by storms and the currents in the lake and river. The timber superstructure will also have to be renewed from time to time, or replaced by stone or iron.

Repairs rendered necessary by collisions and storms will also be required.

I estimate that an average yearly expenditure of $8,000 will suffice for the maintenance of this harbor.

It is important that the extension of the north pier, recommended in my annual report for 1877, be completed at an early day. I estimate, therefore, for the next fiscal year the sum of $14,000, and a subsequent annual expenditure of $8,000 for maintenance. This latter estimate is necessarily conjectural, and may be modified by unforeseen demands or changes or plan.

The amount that can be profitably expended during the next fiscal year is $14,000.

Kenosha is situated in the collection district of Milwaukee, Wis. The nearest port of entry is Milwaukee, Wis.

The amount of revenue collected at the nearest port of entry during the last fiscal year was $171.847.67.

The general commerce of the lakes, as well as the local commerce, is benefited by this harbor.

The number of vessels arriving and departing from this port for the past fiscal year is reported as follows:

	No.	Tonnage.
Arrivals	237	30,149
Departures	241	30,533

Boats having coasting or through manifests do not report here, although they often stop and discharge and take on parts of their cargo. They are not included in the above.

Money statement.

July 1, 1879, amount available	$7,083 82	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$12,083 82
July 1, 1880, amount expended during fiscal year		5,437 66
July 1, 1880, amount available		6,646 16
Amount (estimated) required for completion of existing project		62,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		14,000 00

Abstract of proposals received and opened August 28, 1879, for "Improving harbor at Kenosha. Wis."

PIER EXTENSION AND SUPERSTRUCTURE.

Number and name.	Residence.	Pine timber, 84,528 feet, b. m. (per M, b. m.).	3" pine plank, 3,000 feet, b. m. (per M, b. m.).	Iron drift-bolts, 11,630 pounds (per pound).	7" spikes, 500 pounds (per pound).	Stone, 237 cords (per cord).	Framing timber, 84,528 ft., b. m. (per M, b. m.).	Total cost of one crib and superstructure under each bid.
1. F. M. Knapp & E. Gillen.	Racine, Wis.	$13 75	$9 50	$0 03.15	$0 04	$7 25	$4 00	$3,633 46
2. F. F. Lovell & Co.	do	14 00	10 00	03	04¼	7 50	9 00	4,121 79

Contract made September 1, 1879, with Knapp & Gillen, for pier extension and superstructure, at prices given in their proposal above.

D D 4.

IMPROVEMENT OF HARBOR AT WAUKEGAN, ILLINOIS.

The river and harbor act approved June 14, 1880, appropriated for harbor at Waukegan, Ill., $15,000:

Provided, That this sum shall not be expended until a Board of three Engineers shall have been convened and selected the site, and until the same and a free right of way to all points of the harbor shall have been transferred or relinquished, free of cost, to the United States.

HISTORY OF THE WORK.

In 1852 an appropriation of $15,000 was made for the "improvement of the harbor and breakwater at Waukegan, Ill." There was no harbor whatever there at that time, and the commerce was carried on from bridge piers or wharves in the open lake.

The plan adopted was a breakwater parallel to the shore in 20 feet of

water, placed opposite the heads of two of the bridge piers, so that vessels could lie at the latter in rough weather. One crib, 30 feet long and 25 feet wide, was placed in position, but afterwards carried away by a storm. Whether the crib was properly filled with stone is not known. The work was then abandoned. In 1872 I had an examination made with reference to constructing a harbor at this point, in pursuance of the river and harbor act of June 10, 1872. I submitted a plan for an outside harbor by inclosing a portion of the lake by a breakwater and piers. The breakwater was placed in 24 feet of water. My report on that examination is printed in the Report of the Chief of Engineers for 1873, page 247. No action was taken on that report.

The river and harbor act approved March 3, 1879, directed another survey of "Waukegan Harbor, Illinois." The subject of outside harbor having been discussed in my former report, I directed my attention to the remaining possibilities of making a harbor at this point. A survey was made in September, 1879, and my report was published in House Ex. Doc. No. 19, Forty-sixth Congress, second session. The character of harbor improvement required at this locality for local commerce is somewhat different from that at other points on the great lakes. Most of the harbor improvements on the lakes have consisted in deepening the mouths of streams emptying into the lake. There is a stream emptying into the lake at Waukegan, but it is of no importance for harbor purposes. The only natural feature favorable to a harbor at Waukegan consists in the low ground between the bluffs on which the city is situated and the lake. This ground has but a slight elevation above the lake, is composed of sand, and in it an artificial basin of any desired extent could be easily excavated by dredging. There is a bayou of little depth, known as Little Dead River, running through this low ground parallel to the lake. This bayou is filled with surface water and by percolation of lake water through the sand. At times it discharges into the lake. With a view of eventually utilizing this bayou for an interior basin for harbor purposes, I located the proposed harbor at its mouth.

The objects sought to be accomplished by the proposed harbor were as follows: 1st. To provide, at a minimum cost, a small harbor to meet the immediate wants of commerce at this locality. 2d. To so locate it that its capacity could be readily enlarged from time to time by dredging through the inlet and excavating a basin in the low ground. This work to be done as called for by the necessities of commerce. 3d. To provide a harbor which would afford the necessary protection for the appliances and materials for the construction of a large harbor of refuge, should one ever be made, as had been frequently suggested, at this locality.

The location at the mouth of Little Dead River was selected because the amount of excavation to reach the interior basin would be a mininum at that point.

The citizens of Waukegan objected to the location as being inconvenient (the mouth of Little Dead River being 3,400 feet north of the foot of Washington street, the principal street of the city leading to the lake) and involving the making of a road to the harbor.

PROPOSED APPLICATION OF FUNDS AVAILABLE FOR EXPENDITURE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

As soon as the location of harbor is decided on it is proposed to apply the available funds to constructing a portion of the north pier, commencing at the shore line.

PROPOSED APPLICATION OF FUNDS ASKED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

It is proposed to apply these funds to the construction of piers and dredging, in accordance with the plan adopted.

The letter of March 17, 1879, calling for annual reports, asks for specific statements on certain points, numbered from 1 to 10. These are given below in the same order as far as applicable to this work.

The plan proposed is the inclosing of a small basin in the lake by two piers projecting from the shore, similar to that proposed in my report on survey of Waukegan Harbor dated October 30, 1879.

The exact plan cannot be made until after the location of the harbor is decided on.

The original estimated cost as given in the above mentioned report is	$110,000
Amount since appropriated	15,000
Amount that can be profitably expended during next fiscal year	50,000

The nearest collection district is Chicago, Ill. The nearest port of entry is Chicago, Ill.

There being now no harbor facilities at this point, except one bridge pier in the open lake, very little commerce is carried on by water. It is believed that as soon as a harbor is made where vessels can lie in safety while in port, a large business now done by railroad will be done by vessels, and that considerable business will be developed which does not now exist, owing to the want of a harbor.

Money statement.

Amount appropriated by act approved June 14, 1880	$15,000 00
July 1, 1880, amount available	15,000 00
Amount (estimated) required for completion of existing project	95,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	50,000 00

SURVEY OF WAUKEGAN HARBOR, ILLINOIS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., October 30, 1879.

GENERAL: I have the honor to transmit herewith a report of Mr. W. H. Hearding, assistant engineer, on a survey of Waukegan Harbor, made in pursuance of the act of Congress making appropriations for rivers and harbors, approved March 3, 1879.

An appropriation for the "improvement of the harbor and breakwater at Waukegan" of $15,000 was made by the harbor and river act approved August 30, 1852. Work was commenced on the construction of a breakwater to cover the heads of the bridge piers in the lake. One crib, 30 feet long and 25 feet wide, was placed in position but afterwards carried away by storm. Since then nothing has been done.

An examination or survey was directed at this point by the harbor and river act approved June 10, 1872. I made a report on this examination (see Report of Chief of Engineers for 1873, p. 247). As I then stated, there is no natural harbor at this point. The commerce of the place has always been carried on from bridge piers in the open lake. The local commerce did not at that time appear to warrant any expenditure by the government for harbor purposes, and a plan was submitted for a harbor of refuge by inclosing a portion of the lake by a breakwater and piers.

As preliminary to the construction of this harbor it was proposed to improve the mouth of the river, at a cost of about $75,000, in order to afford a protection for constructing cribs for the breakwater. Such a harbor would, it was supposed, also meet the local wants of the place. A further examination of the locality has been made this season and a more thorough investigation of the subject, owing to the interest which has been manifested by the citizens.

The chart of the coast of Lake Michigan by the United States Lake Survey in the vicinity, recently published, has been of great assistance.

These examinations have resulted in a modification of the former plan, and one is now submitted which will meet all the present wants of local commerce and afford a harbor of refuge for a large class of vessels drawing not more than 10 feet of water.

This plan will admit of enlargement as the future demands of commerce may require, and it will also furnish the necessary protection for the construction of an outer harbor of large size, should one be made at this locality. The plan consists of two piers extending from the shore into the lake, as shown in the accompanying plan.

A basin is thus formed, having an area of 16 acres, and a dock front of 1,260 feet, protected from storms from all directions. The basin is to be excavated to a depth of 12 feet, and the shore line docked to prevent the washing of the bank and to afford a landing place. The location selected for this harbor is opposite the mouth of what is called Little Dead River, a bayou of little depth running parallel to the shore for a distance of about 8,000 feet in high-water, and which, at times, discharges through the inlet. The land between the shore line and the bluffs on which the town of Waukegan is located is a low, sandy plain.

The capacity of the harbor can be enlarged at any time in the future by dredging through the inlet and excavating a basin in the low ground. This can be done to any extent required. A proposed line of this dredging is shown by the dotted lines. Should an increased depth of water be needed, it is only necessary to extend the piers (see dotted lines) and dredge between them to the required depth.

It is proposed to construct the piers inclosing the harbor of two rows of piles filled in between with stone in the following manner:

1. Two rows of piles 12 feet apart, on the inside; to be driven close and 24 feet below water-level. Outer row of piles 12″ × 12″ square timber; inner harbor row 8″ × 12″ pine.

2. On the pier side of the inner row, drive 2 rows of close piling (pine) 3″ thick (each row), 16 feet below water-surface.

3. All piles to be driven by the water-jet system or steam-hammer so as to make the inside row sand-tight.

4. The two rows of piles to be bound together by oak wales connected by iron tie-rods. The wales to be 10″ × 10″, 20 feet long, and each pair connected by 3 rods 1½ inches in diameter, placed 8 feet apart. The rods to be slipped down through narrow slits cut in the piling, and the wales forced a foot or more under water.

5. The space between piles to be filled with stone.

A plan and section of the pier is submitted herewith and also a tracing, showing survey of locality and proposed harbor.

The estimated cost of the work is $110,000. (See accompanying report of Mr. Hearding.) General Orders No. 2, Headquarters Corps of Engineers, dated March 15, 1879, calls for, as required by law, "full statements of all existing facts tending to show to what extent the general commerce of the country will be promoted by the several works of improvement contemplated by such examinations and surveys, to the

end that public moneys shall not be applied excepting where such improvements shall tend to subserve the general commercial and navigation interests of the United States" (joint resolution of Congress of July 27, 1867); also "the amount of tonnage or commercial business during the previous year at each point, together with such other facts as bear on the question of the proposed improvement." All the obtainable facts bearing on the subject are given in Mr. Hearding's report.

A harbor here would also furnish an excellent life-saving station at an important point, there being no harbor between Kenosha and Chicago, a distance of 52 miles.

Should an appropriation be made for this harbor, it should be on condition that the local authority provide a free right of way to all points of the harbor, for the government and the general public, and that the government shall be at no expense in acquiring title or right to use of any land required for the construction or use of the harbor.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. H. HEARDING, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Milwaukee, September 29, 1879.

SIR: In pursuance of your order, I have the honor to state that in the early part of the present month I proceeded to Waukegan, Ill., and made a survey of a section of Lake Michigan and shore in front of the city of Waukegan, a plat of which I herewith respectfully submit for guidance in determining the selection of a site for constructing a harbor at that point, which will best subserve the wants of the local commercial interests of the place, and also be capable of being rendered an important factor in future operations, should it be considered essential to the interests of the general commerce of the lakes, to construct a harbor of refuge at that point. Having in view the probability of such future necessity, and a due consideration of the physical characteristics of the locality, together with an economic application of such funds as may be hereafter made available for the proposed project, it is evident that the minimum quantity of excavation would be obtained by commencing such a project in front of the mouth of the bayou which is known as the Little Dead River, provided the construction of an interior basin should be decided upon as necessary to the protection of general commerce.

The grounds upon which such assumption is based, are first, the general contour of the surface, a mean level of which is shown by the lines of levels taken, to be at about the plane of the present low-water level of the lake, which is 1.3 feet lower than it was during the season of navigation in 1878; and secondly, the construction of such an interior basin, westward of the mouth of the bayou, would in no wise interfere with any personal interest, the proposed site not being at the present time utilized, and consequently of no present monetary value. The creek which divides the southern from the northern section of the city is insignificant, and has no important bearing upon the selection of a site, as the flat in the vicinity of its debouch is contracted and is built over to a great extent; moreover the lake bed in front of the creek is not comprised of as favorable a character of material for excavation as that in front of the bayou.

The distance from the shore line in front of the bayou to the line of 12 feet of water, upon a due east course (present stage), is 1,100 feet; to the line of 18 feet of water it is 2,100 feet.

A well from which the water is obtained for supplying the locomotives of the Chicago and Northwestern Railroad Company is situated near and to the westward of this point upon the line of the railroad, the ground being about 5 feet above lake level.

This well was bored to a depth of 20 feet, the upper stratum, 17 feet in thickness, being an accretion of sand and gravel, and the lower 3 feet into a substratum of blue clay.

I learned, from what I considered reliable authority, that wells have been bored in this vicinity to a depth of 40 feet in the blue clay. This testimony would show that no apprehensions need be anticipated of finding a rock formation as near the lake level as excavation would be required in carrying out the proposed project. The whole flat in front of the face of the plateau has evidently been formed by the successive growths of shore accretions. I made an attempt to verify this apparent certainty by boring, but the only available apparatus I had at command was unsuited to the purpose, and broke at a depth of 6½ feet below the lake level. From the evidence above cited and my own personal convictions concerning the character of the material necessary to be removed in effecting the proposed improvement, I considered it unnecessary to pursue this portion of the subject further.

The plan which you proposed, and which is shown upon the map, of first constructing a small harbor immediately outside the shore-line impresses me most favorably, for it could be built at a comparatively small cost, and would be of a capacity sufficiently large to meet the requirement of the present local commerce, and also if a harbor of refuge for the general commerce of the lakes is decided to be necessary at this point, such a preliminary harbor would be of the greatest service in protecting the cribs while in process of construction for the formation of a breakwater, or it would form a prominent adjunct to the construction of an inner harbor; in fact some such shelter as it would afford would be absolutely necessary to the commencement of any project of the kind upon this exposed coast.

From the information I obtained during the time I was engaged in making the survey, I infer that the prosperity of the city is on the decline, through the lack of facilities for conducting the business which naturally belongs to it.

Its position entitles it to a share of the business of the fertile country which adjoins it on the westward, and which it is asserted is diverted from its natural course by the lines of road which cross this section of country which should naturally contribute to the business of the place. Waukegan is situated at a distance of 35 miles to the northward of Chicago, and 48 miles to the southward of Milwaukee, but I am informed that the cost of transporting freight by the Chicago and Northwestern Railroad is greater from Chicago to Waukegan than it is all the way through from Chicago to Milwaukee. The cause of this apparent anomaly is obvious. The daily lines of steamers which leave Chicago for Milwaukee and other points come into fair competition with the railroad interests and the rates of tariff are governed thereby, but as no accommodation is offered to vessels or steamers at Waukegan, the transportation of almost all articles of merchandise required for the trade of the place is monopolized by the Chicago and Northwestern Railroad. There were formerly two or three bridge piers which could be approached in fair weather by vessels of light draught, and over which quite extensive shipments of grain were conducted, but the construction of the railroad and the increased draught of vessels of more recent build have rendered the meager facilities for doing that class of business of but little value. There is yet one bridge pier in fair condition remaining, which is solely used by its proprietors for the receipt and transmission of lumber, and to which vessels drawing not more than 7 feet of water can approach in fair weather.

As an illustration of the disadvantage at which Waukegan is placed, it may not be improper to narrate a circumstance which occurred during the past summer. The proprietor of the hotel where I stopped was notified to prepare himself to entertain a large party of excursionists on the ensuing day, which notice he accordingly acted upon.

A steamer, drawing 7½ feet of water, with 400 persons on board, arrived off Waukegan at the appointed time, but owing to the shallowness of the water alongside the pier the passengers were unable to effect a landing, although the lake was calm, and the entertainment provided by the hotel proprietor was left upon his hands.

Although the lack of facilities above stated militates seriously against the continuous prosperity of the place, it will be seen from the following statement, kindly furnished by Mr. H. Whitney, county surveyor, that the partial paralysis produced thereby has not so far reduced its importance as to render it insignificant. He says the number of business establishments is 86. The lumber, coal, merchandise, and manufactures annually sold are to the value of $1,100,000.

The wind-mill and pump factories sell yearly $75,000 of those articles. There are 4 wagon-factories in operation; 3 tanneries, which have used 1,500 cords of hemlock bark since April last; 1 scale factory; 2 planing mills; 1 iron foundry; 1 plow factory; 1 woolen mill; 3 breweries; 6 harness shops; 2 brick yards; 3 lumber yards; besides blacksmiths; cooper's shops, gunsmiths, &c. About 4,000 tons of coal are shipped by railroad to this place and consumed annually. It is estimated that an annual saving of $4,000 on the freight of this commodity alone would be effected, if it could be delivered by water transportation, and on other articles correspondingly.

It is said that farmers in the neighborhood resort to Chicago or Kenosha for lumber, &c., in preference to purchasing the same at Waukegan, the rates at which the merchants of those places can obtain freights, giving them an advantage in prices which

persons doing business at Waukegan do not possess. It is further claimed that with proper harbor facilities an extensive grain trade would be re-established, and that general commerce would revive.

There are without doubt valid reasons which commend themselves favorably to the consideration of constructing a harbor of refuge at this point, to which the following list of disasters to vessels bear evidence. It is not asserted that all of these accidents would have been prevented had there been an available shelter at hand, but it is thought that a large amount of life and property could have been saved through such instrumentality.

Since the year 1852 the following vessels have been driven ashore or lost, within a distance of 6 miles of Waukegan, some partially, others totally, destroyed. The schooner C. C. Trowbridge in 1853; the schooner Kate Richmond in 1856; the bark Constitution in 1856; the bark S. F. Gale in 1857; the schooner Two Charlies in 1857; the schooner Ostrich in 1860; the schooner Gazelle in 1865; the schooner Rob Roy in 1867; the schooner Telegraph in ——; the schooner Oliver Culver in 1868; the schooner Ocean Wave in 1872; the schooner Hope in 1873; the schooner Minnie Corbett in 1873; the schooner Una in 1878.

The steamer Lady Elgin sunk September 7, 1860, in which disaster a very large loss of life was sustained. The steamer Sea Bird burnt April 9, 1868, 70 lives lost; only 1 saved.

I have drawn a plan of the pile pier which you propose for the protection of the harbor, in accordance with the specifications furnished; the piles to be driven by means of a water-jet, an estimate of the cost of which is as follows, viz:

FOR A SECTION OF PIER 20 FEET IN LENGTH.

For 20 piles 12″ by 12″ by 30′ square pine timber, 7,200 feet b. m., at $16	$115 20
For 20 piles 8″ by 12″ by 30′ sawed pine timber, 4,800 feet, b. m., at $16	76 80
For 40 plank 3″ by 12″ by 22′, pine, 2,640 feet, b. m., at $14	36 96
For 2 oak wales 10″ by 10″ by 20′, 333⅓ feet, b. m., framed and in place, at $36	12 00
For 3 round iron rods, 1½″ diameter, each 15′ 10″ long, nuts and washers, 300 pounds, at 5½ cents	16 50
For 22 cords of stone, at $7	154 00
For driving 80 piles, square and sheet, at 50 cents	40 00
Total estimated cost of 20 feet of pier	451 46

Or $22.57 per running foot of pier.

The boundaries of the proposed harbor, carried to a depth of 12 feet of water in the lake, exclusive of docking in front of the shore line, are 2,590 feet in length, which, at $22.57 per running foot, equals $58,456.30. The docking required in front of the shore line is 1,260 feet long, which, at $8 per running foot, equals $10,080.

The quantity of material requiring to be excavated to give an uniform depth of 12 feet of water over the entire area of the basin is 228,846 cubic yards, which, at 15 cents per yard, would cost $34,326.90.

RECAPITULATION.

2,590 feet of pile pier, at $22.57	$58,456 30
1,260 feet of shore line to be docked, at $8	10,080 00
228,846 cubic yards of excavation, at 15 cents	34,326 00
	102,863 20
Contingent expenses	7,136 80
Total cost of proposed harbor	110,000 00

The above is respectfully submitted by your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Bvt. Col. D. C. HOUSTON,
Major of Engineers, U. S. A.

ADDENDA.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 12, 1879.

GENERAL: I have the honor to inform you that I omitted to state, as intended, in my report on survey of Waukegan Harbor, dated October

30, 1879, that the location of the proposed harbor as therein stated could be changed to any point in the immediate vicinity, if thought advisable, without materially affecting the cost. I would respectfully request that this letter be appended to the report.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

D D 5.

IMPROVEMENT OF THE FOX AND WISCONSIN RIVERS.

CONDITION OF THE WORK JUNE 30, 1880.

Fox River.

The improvements on the Fox River from Portage to Green Bay, a distance of 160 miles, were purchased by the government, of the Green Bay and Mississippi Canal Company, in 1872. These improvements consisted principally of twenty-two locks, eleven dams, 7½ miles of canal, waste-weirs, and accessory works. The locks and dams were of a temporary character and in bad condition. With one exception the locks were constructed of rough stone walls, without mortar, lined with timber and plank.

On the Lower Fox the maximum depth for navigation was not to exceed 4 feet. On the Upper Fox navigation was suspended at low-water. The plan of improvement contemplated rebuilding *all* the locks and dams except one lock; the construction of five additional locks and dams on the Upper Fox, and deepening and widening the channel for 6 feet draught. This included the making of a number of cut-offs on the Upper Fox, which is a very tortuous stream. In carrying out this plan, it was necessary to make extensive repairs to the old work in the interest of existing navigation as well as to furnish means of transportation for materials required for the construction of new works. The new locks were to be of masonry, laid in cement, with faces of cut stone, and dams of masonry, or timber cribs filled with stone. With the exception of the few miles of canal, the work contemplated was almost equivalent to an *entire new work*, for although the existing work facilitated the operations, the expense of repairs and maintenance of works of that character has been large.

WORK DONE.

Work was commenced in 1873, and up to the close of the fiscal year ending June 30, 1880, the following work has been done in carrying out the plan:

On the Lower Fox six new masonry locks have been built, replacing seven of the old locks; seven dams, one of masonry and six of crib-work filled with stone, replacing seven old dams; the channel has been deepened so as to give over 5 feet navigation in ordinary stages. All of the old locks have been overhauled and repaired as far as they admitted of it; a new retaining wall of solid masonry, 800 feet long and 21 feet high,

for the canal at Appleton has been nearly completed; the canal banks have been strengthened, old waste-weirs repaired, and new ones put in; stone has been quarried and dressed ready for three new locks.

On the Upper Fox five new masonry locks have been built and five new dams; four of these dams are of brush and stone, which method of construction was adopted on account of the limited amount of funds available at the time. The Portage Canal, connecting the two rivers, 2¼ miles in length, has been deepened to 6 feet, widened to 75 feet, and the sides revetted with timber and plank secured by piling. A large amount of dredging has been done on the Upper Fox. Eleven cut-offs have been made with a total length of 5 miles, and width varying from 60 to 100 feet. During the last two years 776,687 cubic yards of material have been excavated by dredging in the Upper Fox. Except at a few points there is now 3 feet depth of water throughout the Upper Fox at low-water. There are now seven dredge-boats, belonging to the work, which will be used for widening and deepening the channel to a depth of 5 or 6 feet. Four new dwellings for lock-tenders have been built.

WORK TO BE DONE.

On the Lower Fox, rebuilding ten locks and one dam; deepening channel to 6 feet; constructing guard gates at heads of canals at Menasha, Appleton, Kaukauna, Rapid Croche, and Little Kaukauna; constructing waste-weirs in dams at Menasha, Little Chute, and Kaukauna; completing revetment wall of canal at Appleton; completing Little Chute Lock and embankments; lengthening Rapid Croche Lock; building lock-tenders' dwellings; strengthening and paving canal banks.

On the Upper Fox, rebuilding four locks at Portage, Governor's Bend, and Montello, and two dams at Governor's Bend and Montello; widening canals at Berlin, White River, Princeton, and Grand River, and protecting banks; protecting river banks where they are liable to wash; dredging channel of river to 6 feet in depth and 100 feet in width, and placing buoys to mark channel; building lock-tenders' houses at White River and Governor's Bend.

WISCONSIN RIVER.

No work of consequence had been done on this river when operations were commenced in 1871. The plan thus far pursued has been to improve the natural channel of the river by reducing its width so as to increase the depth by concentrating the force of the current in a narrower channel. The bed of the river being sand, it yields readily to this increased force. The natural channel of the river is divided by numerous islands, and in carrying out the plan the object has been, first, to confine the river to a single channel and then to gradually reduce its width until the required depth should be attained. This system was carried out up to 1875, when, owing to expressions of dissatisfaction as to the results and progress of the work, operations were confined to short sections of the river looking to its contraction to the width necessary to produce the required depth. Work was directed to this end during the season of 1875.

In 1876 no appropriation was made until August 14, and the funds available were necessary to carry on the works which had been commenced on the Fox River, and from their character could not be stopped without great loss; consequently work was suspended on the Wisconsin. In 1877 no appropriation was made for rivers and harbors. No work was done on the river in 1876 and 1877. In 1878, after the passage of

the appropriation of June 18, work was resumed on the Wisconsin, and has since consisted principally in repairs of dams and protections of the shore from the abrading action of the current. The total amount of work done on the river up to June 30, 1880, is as follows:

157 dams; total length, 76,684 feet.
6 shore protections; total length, 5,714 feet.
1,523 snags removed.
7,332 leaning trees felled.

This work is in two sections: 1st, from Portage to Prairie du Sac; 2d, from Lone Rock to Boscobel; a total distance of 50 miles.

In 1879 the subject of improving the Wisconsin River was referred to the Board of Engineers for fortifications and for River and Harbor Improvements. The Board made an examination of the river in September, 1879. A copy of the report of the Board is forwarded with this report.

The Board was called upon to submit a report and plan of such method of improvement as is contemplated in the act of Congress approved July 7, 1870, as follows:

That the Secretary of War is hereby authorized to adopt for the improvement of the navigation of the Wisconsin River such plan as may be recommended by the Chief of the Bureau of Engineers.

The Board did not discuss any other method than the one which is being carried out, and the conclusions arrived at are as follows:

The works for the improvement of the river, although ameliorating the navigable draught, wherever these have been applied, have not been sufficiently decisive in results to enable the Board to recommend their application to the whole length of the channel without the aid of further information.

We think, therefore, that the section of the river already partially operated upon, from Portage for a length of about 12 miles, should receive additional wing-dams, and the width of the low-water channel should be contracted to 300 feet.

As this section has a slope exceeding somewhat the average, we think the results will be decisive, and if the channel be improved, for a reasonable amount, to an adequate depth, the application of the same system to the rest of the river could be confidently recommended.

While these works are under construction, frequent gaugings should be made to determine the volume passing through the channel at different stages, say at Portage, Dekorra, and Skinner's Bluffs. Also frequent soundings in the deepest part of the channel should be made through the improved section with such angular measurements as will enable the track followed by the boat to be laid down in each case upon the map. These soundings should be referred to an absolute datum, by benches carefully established.

The estimated cost of the work now proposed is $80,000.

Wherever the channel had been contracted to 300 feet ample depth was found, and the shoal places less than 4 feet were found where it was evident the channel was too wide. The plan had not been completed over a sufficient length of river to actually demonstrate its success. This was due to the interruption of the work above stated.

The amount of work required to contract the channel to 300 feet at the upper end near Portage, gradually widening to 500 feet near the mouth, is estimated approximately as follows:

300,000 linear feet brush and stone dams, at $3.25 per foot	$975,000
Canal from Wisconsin River to Prairie du Chien, 4 miles in length	400,000

The estimated cost of completing the improvement of the Fox and Wisconsin rivers, made in 1874, was—

For the Fox River	$2,668,400
For the Wisconsin	930,705
Total	3,599,105
There has since been appropriated	1,295,000
Leaving	2,304,105

An additional estimate for canal at mouth of Lake Winnebago of $146,558 was made in annual report of 1876, increasing the above amount to $2,450,663.

It is evident from our experience that the cost of improving the Wisconsin will be much greater than the estimate, but the work on the Fox will be done under the estimate. The estimate of $1,000,000 for dredging in the Upper Fox will be reduced one-half by the government owning its own dredges.

Navigation being open on the Fox, and the government owning its boats, the cost of transportation of materials will be reduced to a minimum. The estimate for canal from Wisconsin River can also be reduced, so that I think it safe to say that the improvement on the present plan can be completed or made available at a cost not far from the estimate, provided that adequate amounts are annually appropriated. For the past four years the average annual appropriation has been $167,500, which is evidently inadequate in view of the character and magnitude of the work.

If it be a desirable object to open navigation from the lakes to the Mississippi by way of the Fox and Wisconsin rivers, the amount estimated is a small sum for such a purpose. That it was considered by Congress a desirable object is evident from the act of Congress approved July 7, 1870, entitled "An act for the improvement of water communication between the Mississippi and Lake Michigan by way of the Fox and Wisconsin Rivers," which provides—

> That the Secretary of War is hereby authorized to adopt for the improvement of the navigation of the Wisconsin River such plan as may be recommended by the Chief of the Bureau of Engineers.

There is no limitation as to plan or cost. This act also provided for the purchase from the Green Bay and Mississippi Canal Company of its improvements on the Fox River, which involved almost their entire reconstruction, as heretofore explained.

PROGRESS DURING FISCAL YEAR ENDING JUNE 30, 1880.

Fox River.

Lower Fox.—Construction of new lock at Little Chute to replace old first and second locks; construction of revetment wall of Appleton Canal; quarrying and dressing stone for new locks; repairs of old works; strengthening canal banks; repairing break in canal bank at Menasha; construction of waste-weir in third level, Appleton Canal.

The old locks require constant repairs and should be replaced by permanent works.

Upper Fox.—The principal work on this portion of the river during the year has been dredging to deepen and widen the channel and make cut-offs at the most difficult bends. Five dredges have been employed, including one pump-dredge. They worked at different points between Berlin and Governor's Bend Lock. The total amount of material excavated during the year is 460,931 cubic yards, of which 49,000 cubic yards was handled twice. The pump-dredge was used largely in washing down banks cast up by the other dredges.

In addition to dredging, the following work has been done: The guard-lock at Portage has been thoroughly repaired; the dams at Eureka, Berlin, White River, and Princeton repaired and strengthened; the river cleared of snags, and all boats, dredges, &c., repaired.

Wisconsin River.

Last season, after July 1, slight repairs were made to dams between Portage City and Wild Cat Bluffs, a distance of 12 miles, and three dams were extended on this section, making a total extension of 1,520 feet.

At the request of owners of a steamboat running from Portage to Sauk City, five dams were built on a stretch of 2 miles of river just above Prairie du Sac, having a total length of 4,625 feet.

This spring work was commenced on the upper section to reduce width of low-water channel to 300 feet, as recommended by the Board of Engineers. One dam was extended 530 feet. Brush and stone were collected for other dams; when operations were stopped by an unusual flood in the river, the water rising 7.1 feet above the zero of the gauge at Portage or 7.9 feet above the lowest water on record, that of 1877.

For further details in reference to the work done I refer to the accompanying reports of First Lieutenant F. A. Hinman, Corps of Engineers, and C. A. Fuller, assistant engineer.

PROPOSED APPLICATION OF FUNDS AVAILABLE FOR EXPENDITURE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

Fox River.

Lower Fox.—Completing revetment wall of canal at Appleton; completing new lock and embankments at Little Chute; constructing wasteweir in Little Chute Dam; transporting stone for new locks to lock sites; quarrying and dressing stone and work necessary for maintenance of navigation.

Upper Fox.—The dredges will be employed in widening and deepening the channel and in making cut-offs; building lock tender's dwelling at White River; repairing Montello and Governor's Bend locks, and work necessary for maintenance of navigation.

Mouth of Fond du Lac River.

Deepening channel by dredging.

Wisconsin River.

Construction of additional wing-dams for a distance of 12 miles below Portage, so as to reduce the width of low-water channel to 300 feet.

PROPOSED APPLICATION OF FUNDS ASKED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

Continuation of operations in accordance with plan heretofore described.

RESERVOIRS.

The report of Major C. J. Allen, Corps of Engineers, on the subject of reservoirs on the headwaters of the Mississippi and its tributaries, House Ex. Doc. No. 39, Forty-sixth Congress, second session, states, with reference to the Wisconsin River, that, "with the reservoirs now found practicable, we can deliver, in round numbers, 2,300 cubic feet per second for a period of ninety days." His estimated cost for six reservoirs is $170,978. The estimated cost of the largest reservoir, that on the Wisconsin at Otter Rapids, calculated to deliver 950 cubic feet per second for ninety days, is $38,113. These estimates are exclusive of land damages, which it is thought would be small.

The low-water discharge of the Wisconsin at Portage in 1879 was about 2,400 cubic feet per second, so that it is evident that, with the channel of the river confined as is now being done, an increment of 2,300 cubic feet per second, or even 950 feet, would be a great benefit to navigation, and would probably reduce the amount of work now contemplated in improving the river channel.

I would, therefore, recommend that so much of the appropriation asked for year ending June 30, 1882, as is necessary, be made available for the construction of one or more reservoirs on the Wisconsin River as part of the improvement of that river.

The letter of March 17, 1879, calling for annual report, asks for specific statements on certain points numbered from 1 to 10. These are given below in the same order.

The plan adopted for this work is, for the Fox River, slackwater navigation by dams and locks, and for the Wisconsin, the improvement of the natural channel of the river by means of wing-dams and dikes, so as to reduce the width of the river where necessary at low-water, and by thus confining the current secure an increase of depth by the scouring action of the current.

Original estimated cost of work as now being carried on	$3,745,663 00
Amount appropriated since adoption of present project	1,295,000 00
Amount expended since adoption of present project, *i. e.*, since July 1, 1875	1,126,390 90
Amount, exclusive of former appropriations, required for entire and permanent completion of work	2,450,663 00
Amount that can profitably be expended during next fiscal year	500,000 00

The nearest collection district is Milwaukee, Wis. The nearest port of entry is Milwaukee, Wis.

The amount of revenue collected at the nearest port of entry during the last fiscal year was $171,847.67.

The object of this improvement is to establish a water-route between the Upper Mississippi and the lakes, by which transportation will be cheapened.

The arguments on this subject are fully given in the report of Major G. K. Warren, Corps of Engineers, Report of Chief of Engineers for 1868, page 357, and in the report of the select committee on transportation routes to the seaboard, United States Senate, 1874.

Work done by hired labor and purchase of materials in open market.

The amount of tolls collected during the year ending June 30, 1880, is $2,726.08, required to be reported annually by act of Congress approved July 7, 1870.

The following papers are submitted with this report:

No. 1. Report of Board of Engineers on Wisconsin River.

No. 2. Annual report of First Lieut. F. A. Hinman, Corps of Engineers, on Wisconsin River.

No. 3. Annual report of First Lieut. F. A. Hinman, Corps of Engineers, on Fox River, Portage to head of Lake Buffalo.

No. 4. Annual report of Mr. C. A. Fuller, assistant engineer, on Fox River, Lake Winnebago to Green Bay.

Money statement.

July 1, 1879, amount available	$257,692 74	
Tolls received and deposited to credit of appropriation	2,771 66	
Fuel sold to officers and deposited to credit of appropriation	194 00	
Amount appropriated by act approved June 14, 1880	125,000 00	
		$385,658 40
July 1, 1880, amount expended during fiscal year		211,034 63
July 1, 1880, amount available		174,623 76

Amount (estimated) required for completion of existing project........ $2,450,663 00
Amount that can be profitably expended in fiscal year ending June 30, 1882. 500,000 00

WISCONSIN RIVER.

REPORT OF BOARD OF ENGINEERS.

OFFICE BOARD OF ENGINEERS FOR FORTIFICATIONS
AND FOR RIVER AND HARBOR IMPROVEMENT, &C.,
New York, November 24, 1879.

GENERAL: By your letter of September 5, 1879, the subject of the improvement of the Wisconsin River was transferred to this board with directions for it to be guided by the instructions contained in your letter of January 9, 1879, assigning the subject to the Board of Engineers on the improvement of the low-water navigation of the Mississippi and Missouri rivers.

The improvement of the Wisconsin River was proposed with a view to making it navigable by the class of steamers that could pass through the Upper and Lower Fox, with which it is connected by a canal, and thus to open a steamboat transportation route from the Mississippi River to Lake Michigan.

The following is a brief history of this work of improvement by the United States Government.

Under the direction of General G. K. Warren a reconnaissance of the Wisconsin was made in 1866 by Major C. R. Suter, which showed that a thorough survey would be needed before plans and estimates for its improvement could be made. Accordingly such a survey was made, August–November, 1867, from Portage City to the Mississippi, and, April 6, 1868, General Warren submitted a report expressing himself thus:

> From the present state of our investigations, I am in favor of an improvement of the river by dams, jetties, revetments, &c., of brush and stone, in connection with dredging, in preference to a canal along the banks, or to locks and dams in the river;

and he recommended an appropriation of $50,000 "to test this method of improvement more fully than has yet been done."

In his annual report dated August 31, 1868, he submitted detailed estimates for the improvement of the river, as follows:

1. For improvement of the natural channel of the river, for 3 feet navigation, by means of a series of wing-dams and use of Long's scraper. Estimate of cost, $428,000.
2. For 4 feet navigation by use of natural channel, old beds, and side canals built around shallow portions of the river. Estimated cost, $3,207,000.
3. For a canal with 5 feet navigation, the canal to be built along the valley, alternating from one side to the other to keep on most advantageous ground, and using the most convenient places in the natural bed of the river for crossings. Estimate, $4,164,000.

The first plan he considered practical to secure not more than 3 feet of water, but thought it questionable whether it would meet the requirements of the country from which its business would be derived.

The second plan he considered objectionable on account of liability of change in the river during floods, and of the large expenditures necessary to keep the locks in repair and to maintain the channel.

He gave his preference to the third plan on account of its comparative cheapness to construct and economical maintenance, and as affording a reliable water communication.

In his annual report of September 20, 1869, he recommended that

$100,000 be appropriated to test the practicability of improving the navigation by wing-dams before finally resorting to the project of a canal; but in November, 1875, five years after he was relieved from the charge of this work, General Warren submitted a final report, in which he gave his opinion in the following words:

It seems to me, from what I have presented in this chapter, that no satisfactory improvement on the Wisconsin can be made by any system of contraction and rectification.

On the 1st of June, 1870, Col. J. N. Macomb was placed in charge of this improvement. The act of Congress of July 10, 1870, appropriated $100,000 for the improvement of this river by such plan as might be recommended by the Chief of Engineers.

Col. D. C. Houston relieved Colonel Macomb of this work May 5, 1871. Soon after, he was called upon for a project for the expenditure of the appropriation of $100,000 made by the act of July 10, 1870, which had become available. He was instructed to confer with General Warren, under whose direction a survey of the river had been made in 1867. After conference with General Warren, Colonel Houston submitted a project, dated June 10, 1871, for improving the channel at the points where the line of canal proposed by General Warren crossed the river. This canal plan contemplated that boats should pass from the canal into the river and again into the canal at the crossings. It was proposed to ascertain by trial whether the necessary depth could be produced and maintained for this purpose, and whether the natural channel of the river itself could be improved. Colonel Houston's project, which contemplated the contraction of the river by means of wing-dams of brush and stone, was approved June 12, 1871, and operations were at once commenced and continued during the season. The work done and results accomplished were reported December 28, 1871 (see Report of Chief of Engineers 1872, page 135). Owing to the difficulty encountered in procuring materials near the canal crossings, it became necessary to improve portions of the river so that boats could navigate it. There were built during the season 22 dams at the upper and middle canal crossings, with an aggregate length of 6,621 feet, and at a total cost of $31,890. The total length of river over which these works extended was about 7 miles. Their effect was to deepen the channel so that the boats used for transporting materials could navigate these portions of the river. Colonel Houston was satisfied from the season's work that the channel of the river could be improved to a depth of 4 feet, and in all probability 5 feet, and he so stated in his annual report. In February, 1872, he was called upon for a project for expending the balance of the appropriation "directly to the improvement of the natural channel of the river." He submitted a project for this purpose, which was approved and carried out during the season of 1872. In 1873 an appropriation of $300,000 was made for the improvement of the Fox and Wisconsin Rivers; in 1874 one of $300,000, and in 1875 one of $500,000, for the same purpose. In each of these years the projects for expenditure which were approved recommended the application of $100,000 on the Wisconsin and the remainder on the Fox River.

Up to 1875 the work had been carried on with a view of confining the river to a single channel at low-water, and to reduce the width of the widest portions so as to get the river gradually under control and avoid violent disturbance of the bottom, which would result in case the channel were immediately contracted to the width finally necessary.

In this way the work was distributed over a total length of river of 46 miles, in two sections:

1st. From Portage to Prairie du Sac; and,

2d. From Lone Rock to Boscobel.

Considerable dissatisfaction at the progress and plan of the improvement was expressed about 1874, and in 1875 work was confined to short sections of the river in order to demonstrate practically as far as possible the success or non-success of the system.

Owing to insufficient funds to carry on both works of improvement, that on the Wisconsin was suspended during 1876 and 1877. The total work done up to the close of 1875 was as follows:

150 dams, total length	65,971 feet.
4 shore protections, total length	2,293 feet.
1,215 snags removed.	
5,820 leaning trees felled.	
Total expenditures	$337,666 29

In 1878 work was resumed on the upper section, and consisted principally in repairs of dams which had settled, and shore protection.

In 1879 several of the dams have been repaired and extended, and five new dams built in the vicinity of Prairie du Sac, at the lower end of the upper section.

The improvement to close of 1879 extends over about 50 miles of river, and consists of—

150 dams, total length	74,634 feet.
6 shore protections, total length	5,714 feet.
1,523 snags removed.	
7,332 leaning trees felled.	
Total expenditures	$408,814 97

The question submitted to this Board is set forth in the following extract from the letter of instructions of the Chief of Engineers (January 9, 1879) to the Board on improvement of the low-water navigation of the Mississippi and Missouri rivers, to whom this subject was first assigned:

The act of July 7, 1870, contains the following: "*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:*

"That the Secretary of War is hereby authorized to adopt, for the improvement of the navigation of the Wisconsin River, such plan as may be recommended by the Chief of the Bureau of Engineers"; and with a view to determining upon a proper plan to be recommended for adoption, the question of improving the Wisconsin River is hereby assigned to the Board of Engineers on the low-water navigation of the Mississippi River.

* * * * * * *

It is desired that the Board submit a report with plan of such improvement of the Wisconsin River as is contemplated in the above-mentioned act.

Having examined the Wisconsin River, September 19–22, from Portage City to Prairie du Chien, on the steamer Ellen Hardy, drawing 18 inches, and duly considered the results of the system of improvement as applied to this river for the past seven years, and discussed the special questions of slope and water supply in connection therewith, this Board have the honor to submit their views upon the subject presented to them in the following report:

PRACTICAL EFFECTS OF THE IMPROVEMENTS.

To determine the practical effects exerted upon the river by the works of improvement already completed, we have the original survey made by General Warren from Portage to the mouth in 1867; the gaugings made by him, reported on page 83 of his final report; and the table

showing the duration of the different stages of the water surface for the years 1867, '68, and '69, on page 79 of the same report. To compare with these data which exhibit the condition of the river before any work was done upon it, we have a detailed survey made in 1878 by Colonel Houston from Portage City to a point just below Dekorra (about 8 miles) covering a portion of the river where the works have been most systematically carried out; certain gaugings made by him in September and October, 1879; a table exhibiting the duration of the stages of the river at Portage for the years 1871 to 1878, inclusive; and a record of four lines of soundings made in the best channel below Portage, in the low-water stage of 1879.

A critical comparison has been made of these data by the Board, with the following results for the section 8 miles below Portage. The information on hand is not sufficient to extend the discussion beyond these limits.

WIDTH FOR 8 MILES BELOW PORTAGE.

To determine this quantity for the unimproved river, distances of 1,500 feet were laid off on General Warren's map, and the corresponding actual widths of the water-way at a stage 3.6 feet above the upper miter sill of the lock at Portage were measured. This miter sill is 3.05 feet below the zero of General Warren's gauge and 3.25 feet below the zero of the present gauge.

Twenty-eight widths were thus measured, giving a mean width of 687 feet, ranging from 1,200 feet to 430 feet.

Upon the corresponding map of Colonel Houston the widths between the ends of the spur jetties and the opposite shore were measured, giving 30 widths, of which the mean was 432 feet, ranging between 600 feet and 280 feet.

It therefore appears that the width at this stage (0.6 foot above the zero of General Warren's gauge) has been reduced from 687 feet to 432 feet—a diminution of 255 feet, or about 37 per cent.

MEAN DEPTH IN THE BEST CHANNEL FROM PORTAGE TO A POINT 8 MILES BELOW.

To compare this quantity, the line indicated by General Warren on his map was followed, and a mean of all the recorded soundings (138) was taken, giving 5.46 feet for a stage 0.6 feet above the zero of his gauge. Major Houston's map was then studied in the same manner, giving for the same stage (mean of 253 soundings) 6.51 feet.

Hence it appears that the best channel has deepened in this section of the river 1.05 feet at a stage 3.6 feet above the miter sill at Portage. Since, however, the whole regimen of the river has been changed, it does not follow that the same *volume of water* is passing now as in 1867 at a given reading of the gauge; and since this equality affords the only proper standard of comparison, the data was not studied to determine the fact.

VOLUME OF WATER.

General Warren gauged the river in this section four times in 1867 and once in 1878, using the method of mid-depth floats. Colonel Houston did the same eight times in 1879, adopting the same localities and the same plan. The following table exhibits these data:

Gaugings of the Wisconsin near Portage.

Locality.	Date.	Warren's gauge at Portage.	Number of floats.	Discharge in cubic feet per second.
Portage below bridge	Aug. 24, 1867	+0.6	......	3,360
Portage below canal	Aug. 24, 1867	+0.6	......	3,152
Do	Aug. 29, 1867	+0.55	......	3,679
Dekorra	Sept. 2, 1867	+0.5	......	3,558
Portage below bridge	Oct. 19, 1878	+2.85	......	10,000
Do	Sept. 25, 1879	−0.2	11	2,518
Do	Sept. 26, 1879	−0.3	6	2,351
Do	Oct. 6, 1879	+0.6	14	4,124
Portage below canal	Sept. 26, 1879	−0.3	9	2,471
Do	Sept. 26, 1879	−0.3	10	2,443
Below Baraboo River	Sept. 27, 1879	−0.25	6	2,612
Dekorra	Sept. 28, 1879	−0.2	9	2,996
Do	Oct. 7, 1879	+0.65	18	4,076

Throwing out of consideration for present purposes the measurement on October 19, 1878, the remainder are so nearly at the same stage as to render it admissible to assume for them that the change in volume per $\frac{1}{10}$ foot of the gauge is uniformly the same amount, and hence to reduce the several discharges to the same absolute gauge reading for comparison.

What this amount is may be determined in various ways. Thus the gaugings of September 25 and 26, 1879, at Portage below the bridge, show it to be 167 cubic feet.

In like manner the mean of the three gaugings at Portage on September 26, 1879, compared with that of October 6, 1879, shows it to be 189 cubic feet.

The gaugings of September 25, 1879, and October 6, 1879, at Portage indicate 201 cubic feet for this amount.

The gaugings of September 28, 1879, and October 7, 1879, indicate 127 cubic feet at Dekorra.

Adopting the mean of the three values of Portage (186 cubic feet) and of that at Dekorra (127 cubic feet), we have the grand mean, 157 cubic feet, as the average change in discharge due to a change of level of $\frac{1}{10}$ foot in the low-water surface in this section of the river.

Applying this correction to the gaugings at Portage, we find the following values for the discharge at zero of General Warren's gauge:

	In 1867.	In 1879.
	2418	2832
	2210	2822
	2816	3132
	——	2942
Mean	2481	2914
		3004
Mean		2941

It therefore appears that the change of regimen of the river has caused a volume greater by 460 cubic feet per second to pass at Portage, when General Warren's gauge reads zero, than was the case in 1867—*i. e.*, the water plane is lowered 0.29 foot.

If the measurement on August 29, 1867, which General Warren states "seems to be from 300 to 500 feet too large when compared with the others," be thrown out, the change in the water plane becomes 0.4 foot.

At Dekorra a similar discussion indicates 0.26 foot as the probable lowering of this plane.

Hence it appears probable that the river, at the same level about the low-water stage, in its improved condition, carries *a larger volume (about 500 cubic feet per second) than before, the difference corresponding to about $\frac{3}{10}$ foot in the reading on the gauge.* This result is in accord with experience upon the Garonne, where Baumgarten reports that the effect of the improvements was first to raise and then to permanently lower the water level. If so, the increase in the mean depth in the best channel already deduced should be reduced by this amount, making it 0.75 foot for the volume which passed in 1867, when the water showed + 0.6 foot on General Warren's gauge.

DEPTHS ON THE CRESTS OF THE BARS.

For purposes of navigation it is not the mean depth in the best channel, but the depth on the bar crests, which is of practical importance. To compare the river in its two conditions, the surveys have therefore been examined in respect to this quantity. The following table exhibits the results when the *same volume* is passing at a stage corresponding to + 0.6 foot on General Warren's gauge.

Extreme low-water (1878) reads, — 0.6 foot on General Warren's gauge; *hence* 1.2 *feet must be deducted from all the figures in the table to indicate approximately the depth on the bars in the lowest stage on record. For average low-water,* 0.8 *foot should be deducted.*

Least depths on the bars for equal discharges.

Bars less than 3 feet.		Bars less than 4 feet.		Bars less than 5 feet.		Points where depth is greater than 12 feet.	
1867.	1878.	1867.	1878.	1867.	1878.	1867.	1879.
2.8	2.7	2.8	3.7	2.8	4.3	1	10
2.3	2.6	3.2	3.9	3.2	3.7	....	....
....	2.9	3.4	3.7	3.2	3.9	....	....
....	....	3.2	2.7	4.4	4.6	....	....
....	....	3.3	3.5	4.2	4.7	....	....
....	....	3.7	3.7	3.3	4.1	....	....
....	....	3.6	2.6	3.7	3.7	....	....
....	....	3.0	2.9	3.0	2.7	....	....
....	....	3.5	....	3.5	3.5	....	....
....	....	3.8	....	3.7	4.3	....	....
....	....	3.7	....	3.6	4.7	....	....
....	....	3.6	....	4.3	4.9	....	....
....	....	3.2	....	4.2	4.8	....	....
....	....	3.7	....	3.2	4.7	....	....
....	....	3.8	....	4.3	4.5	....	....
....	....	3.8	....	4.0	4.5	....	....
....	....	2.3	....	3.7	4.5	....	....
....	....	3.0	....	3.8	4.6	....	....
....	....	3.7	....	3.8	4.9	....	....
....	....	....	....	2.3	4.5	....	....
....	....	....	....	3.0	4.7	....	....
....	....	....	....	4.5	4.0	....	....
....	....	....	....	3.7	3.7	....	....
....	....	....	....	....	2.6	....	....
....	....	....	....	....	4.9	....	....
....	....	....	....	....	4.5	....	....
....	....	....	....	....	4.9	....	....
....	....	....	....	....	4.5	....	....
....	....	....	....	....	4.7	....	....
....	....	....	....	....	4.9	....	....
....	....	....	....	....	2.9	....	....
....	....	....	....	....	4.8	....	....

A study of this table suggests several interesting conclusions:

1st. The worst bars (those less than 3 feet at this stage) exhibit no improvement. They are, however, now found at points where the river has not been sufficiently reduced in width, and by local jetties they could easily be removed.

2d. The bars with less than 4 feet have been reduced in number from 19 to 8, showing a decided improvement, and they are also much shorter than before.

3d. The bars having less than 5 feet of water have increased in number from 23 to 32, but the mean depth on their crests has also increased from 3.6 feet to 4.3 feet, showing an improvement of about 0.7 foot in average depth. This number, it will be noticed, accords almost exactly with the result reached by comparing the mean depths in the best channel, and suggests the important conclusion that the average depth on the bars injurious to navigation has increased *pari passu* with the mean depth in the best channel.

4th. The effect of the improvements has been to increase the number and reduce the length of the bars, and to increase the number of holes (deeper than 12 feet).

The appended table* (marked I) shows the results obtained in the past season (1879) by passing over the best channel in the improved portion, and recording the soundings taken at short intervals of time, the least depth on the bars being always given. The soundings are recorded as taken and the reductions to low-water may be inferred from the guage readings at the heads of the columns, which refer to the present gauge (zero $\frac{2}{10}$ foot above that of General Warren's).

MOVEMENT OF THE BARS.

Colonel Houston has made some interesting measurements to determine the rate of movement of the bars down stream. He finds that a bar near the bridge above Portage, disconnected from the banks, traveled 940 feet in 24 days, or at a rate of 39 feet daily, at a stage + 1.8 above General Warren's gauge at Portage; and 320 feet in 14 days, or at a rate of 22 feet daily, while the river was falling 1 foot. These rates for a bar connected with one bank were respectively 17 feet and 11 feet daily, at the same dates and locality.

DURATION OF STAGES.

The following table gives a condensed statement of the duration of the different stages of the river during the years 1871–'78. As compared with that on page 79 of General Warren's final report, it indicates that the conditions as to water supply are less favorable than would be supposed from the records at hand when the work of improvement was begun. Since that date very dry seasons have occurred, which, of course, must greatly reduce the volume of the river.

In addition to this natural cause, two or more dams have recently been built across the Upper Wisconsin by lumbermen to float their timber at low stages, which may temporarily affect the volume passing Portage City to a serious degree.

Another possible cause is the cutting of the timber on large areas of forest land in Northern Wisconsin; which, for small rivers, is well known to have a tendency to increase the heights of freshets, and correspond-

* Not printed.

ingly diminish the low-water level, and to decrease the duration of the stages and increase that of low-water stages.

Table showing duration of different stages of water in the Wisconsin River at Portage above or below General G. K. Warren's zero, 3 feet above miter-sill, for the years 1871 to 1878, inclusive.

Year.	Depth 0 to extreme low-water.	Depth 0 to 1 foot.	Depth 1 to 2 feet.	Depth 2 to 3 feet.	Depth 3 to 4 feet.	Depth 4 to 5 feet.	Depth 5 to 6 feet.	Depth 6 to 7 feet.	Extreme low-water.	Gauge record considered—	Total number of days.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*		
1871..	......	39	......	......	......	......	......	......	0+1′	From Aug. 28 to Oct. 5, inclusive.	39
1872..	42	81	30	39	17	5	......	......	0—2′	From Apr. 10 to Nov. 9, inclusive	214
1873..	9	105	34	33	31	16	4	......	0—4′	From Apr. 1 to Nov. 18, inclusive.	232
1874..	44	52	72	25	23	2	......	......	0—4′	From Apr. 17 to Nov. 20, inclusive	218
1875..	5	78	45	35	23	10	......	......	0—2′	From May 9 to Nov. 20, inclusive.	196
1876..	2	43	84	21	30	11	32	23	0—1′	From Apr. 1 to Dec. 2, inclusive..	246
1877..	71	50	77	41	5	......	......	......	0—0′	From Apr. 1 to Nov. 30, inclusive.	244
1878..	23	52	124	30	13	2	......	......	0—5′	From Apr. 1 to Nov. 30, inclusive.	244

SUMMARY.

In brief, the practical results of the improvements in the 8 miles considered seems to be—

1st. The width has been reduced about one-third, at the low-water stage.

2d. The average depth on the bars has been increased about 9 inches at this stage.

3d. The contraction in the width of the river has not been carried sufficiently far nor made with sufficient regularity to prevent the bars from occasionally rising to heights nearly as injurious to navigation as before the improvements were begun, but the number of such bars and their lengths have been materially reduced.

4th. The cost of effecting these results for the 8 miles below Portage has been about $75,000.

PERSONAL INSPECTION OF THE RIVER.

In addition to the foregoing means of information, the board made a personal inspection of the whole river below Portage in September, 1879, when the water stood + 0.1 on General Warren's gauge at the canal lock. The boat employed (the Ellen Hardy) drew about 1.5 feet, and made the trip in four days, passing without difficulty over the improved and partially improved portions, and encountering the worst bars between Sauk City and Richland City, where no work had been done.

The mechanical details of the improvement have evidently received close study, and the work is prosecuted economically and rapidly.

The jetties exhibit a satisfactory degree of permanency—those constructed in 1872 being usually in a fair condition—even those not buried needing but little repairs to make them as good as new.

There seems to be no indication of any tendency to undermining; on the contrary, large bars usually form below the dams, and thus make new low-water banks, which serve to confine the water to a much narrower channel than before.

Except for the 8 miles below Portage no data is at hand upon which to base any detailed estimate of the effect of the works of improvement upon the regimen of the river.

Seven bridges span the river below Portage, and all but two offer serious impediments to navigation.

CONCLUSIONS.

The works for the improvement of the river, although ameliorating the navigable draught, wherever these have been applied, have not been sufficiently decisive in results to enable the board to recommend their application to the whole length of the channel without the aid of further information.

We think, therefore, that the section of the river already partially operated upon, from Portage for a length of about 12 miles, should receive additional wing-dams, and the width of the low-water channel should be contracted to 300 feet.

As this section has a slope exceeding somewhat the average, we think the results will be decisive, and if the channel be improved, for a reasonable amount, to an adequate depth, the application of the same system to the rest of the river could be confidently recommended.

While these works are under construction frequent gaugings should be made to determine the volume passing through the channel at different stages, say at Portage, Dekorra, and Skinner's Bluffs.

Also frequent soundings in the deepest part of the channel should be made through the improved section with such angular measurements as will enable the track followed by the boat to be laid down in each case upon the map. These soundings should be referred to an absolute datum, by benches carefully established.

The estimated cost of the work now proposed is $80,000.

The letter of Maj. D. C. Houston, of August 30, 1879, to the Chief of Engineers, inclosing copy of a letter from Mr. B. J. Stevens, which were referred to the Board by your letter of September 5, 1879, are herewith returned.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brevet Major-General, U. S. A.
JOHN NEWTON,
Colonel of Engineers, Brevet Major-General, U. S. A.
HENRY L. ABBOT,
Major of Engineers, Brevet Brigadier-General.
D. C. HOUSTON,
Major of Engineers, Brevet Colonel.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF LIEUTENANT F. A. HINMAN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., July 1, 1880.

SIR: I have the honor to submit the following report of operations on the Wisconsin River improvement for the fiscal year ending June 30, 1880:

1. DAMS AND BANK PROTECTIONS.

During the month of July the operations commenced in the spring were continued in accordance with the plan then pursued to repair and maintain the work and to construct new work where required in the river for a distance of 12 miles from Portage, Wis., to Wild Cat Bluff. Four dams were repaired between Allen's Flats and Wild

Cat Bluff, viz, Nos. 3, 1872; 15, 1875; 18, 1875; and 8, 1872; the extent of these repairs was in the main very slight. Dam No. 3, 1872, on Allen's Flats, was extended 670 linear feet; dam No. 18, 1875, at Wild Cat Bluff, was extended 350 linear feet, and dam No. 1, 1875, at Portage, was extended 500 linear feet.

The above work completed this section according to the plan contemplated, and as it was thought sufficient to illustrate the system, it was deemed best to suspend further operations until the Board of Engineers that had been convened to prepare a plan for the improvement of the river had inspected and reported on it.

The greater portion of the party was therefore discharged, and the boats were on the point of going out of commission, when a letter (copy appended hereto) was received from Messrs. M. H. Keysar & Co., of Prairie du Sac, Wis., requesting that some work be done in the vicinity of that place. They evidently refer in their letter to the two isolated dams that were built experimentally of sand and brush opposite to the location of their elevator at Prairie du Sac, in October, 1872; of course not a vestige of them remains now; the nearest improvement dam to the sites of them at the date of Messrs. M. H. Keysar & Co.'s said letter was about 3 miles above them.

Messrs. M. H. Keysar & Co.'s request was acceded to by you, and accordingly the quarter boat and eleven scows were floated down to Prairie du Sac. As the tug Winneconne was unable to reach there on account of low-water, the stern-wheel steamboat Ellen Hardy, belonging to Messrs. M. H. Keysar & Co., was chartered to assist in the work, being on the spot.

Sharp's Crossing had for some time been very short and shoal; at low-water last season the least depth on it was 1.5 feet. The best channel between Sharp's Landing and Prairie du Sac Bridge, a distance of 2 miles, had a least depth of 1.2 feet; the wide flat in this portion had been temporarily improved but slightly with brush and saplings by the crew of the Ellen Hardy just before she was chartered.

Actual work on the construction of dams was commenced at Prairie du Sac on August 13 and finished October 11, during which time five dams were built, with an aggregate length of 4,625 linear feet, one of which (No. 3) is the longest piece of work of the kind on the river; it is 1,459 linear feet in length.

The proportion of brush to stone, in cords, used in these five dams is three to one; they cost $2.73 per linear foot. This estimate is based on the ordinary monthly expenses, the plant being furnished. While they were being built the crew of the *Winneconne* removed 172 snags and felled 732 leaning trees. If the cost of pulling each snag be estimated at $1.50, and that of felling each tree at 75 cents, and the total cost of snagging and felling timber be deducted from the total expenses, the cost of these dams per linear foot would be reduced to $2.55. It is customary to employ the steamboats in snagging and felling leaning timber, whenever they can be spared, while a dam is being built.

The river was inspected by the Board of Engineers above referred to, in September, at a low stage of water, and operations were commenced at Portage this spring to improve the first 12 miles of the river below Portage, according to the plan recommended November 24, 1879, by the Board, and approved January 19, 1880, by the Chief of Engineers, viz, to contract the width of the low-water channel to 300 feet by additional wing-dams.

Owing to high-water no brush could be obtained on the bottom lands until May 17, and actual work was not resumed on the dams until May 26. Dam No. 2, 1873, was extended 530 linear feet; the old jetty opposite to it, near the railroad track, was repaired; dam No. 12, 1873, was repaired, and the extension of the same commenced; dams Nos. 1, 1873, and 1, 1875, were repaired, and the repairs of dam No. 1, 1878, commenced; the construction of dam No. 1, 1880, was begun, and bank protection No. 1, 1878, was extended 224 linear feet. Work on the above was suspended June 11 on account of high-water; enough had been done, however, to define the low-water channel of 300 feet in width quite well for a distance of about 1 mile. Work was resumed to-day, as the river has fallen sufficiently to admit of it.

A bank protection 2,475 linear feet in length, built at Portage in 1873 of coarse gravel, above ordinary low-water, and of gravel and brush mats below, was repaired in 1878, and erroneously included as new work in my last annual report. The total number of bank protections to date is six, with an aggregate length of 5,938 linear feet.

The water-jet process could be used to advantage on this work in grading banks for bank protection.

2. SOUNDINGS.

A line of soundings was run from Portage to dam No. 8, 1872, at Wild Cat Bluff, July 25; the gauge reading at Portage on that date was 1.3 feet above zero. A channel at least 4 feet in depth was found, except in two places, where the soundings were 3 feet and 3.8 feet respectively.

On August 25 a line of soundings was run from Portage Bridge to Prairie du Sac Bridge; on that date the gauge reading at Portage was 0.65 of a foot below zero. A

list of these soundings is appended hereto. It is proper to state that the best channel (a poor one) over the flat at Prairie du Sac had just been closed up by dams.

On October 14, three days after the completion of the last dam built at Prairie du Sac, a line of soundings was run from just above Sharp's Landing to the elevator at Prairie du Sac. The gauge reading at Portage on that date was 0.3 of a foot above zero. A list of these soundings is appended hereto. It will be observed that the least sounding is 2.5 feet, and that the channel had improved considerably in a very short time, particularly Sharp's Crossing from Sharp's Landing to dam No. 2, 1879, and also below dam No. 3, 1879.

The ice broke up at Prairie du Sac for the second time during the winter on March 18, and the river was free from it at that point on and after March 20. It was at a low stage for some days thereafter. On March 22, Mr. Michael Ward, watchman, in accordance with instructions, sounded the channel from Sharp's Landing to Prairie du Sac Bridge, and reported that the least depth found was 4 feet; that the dams were all in fine condition, and that the channel ran along Long Island as had been projected. The gauge reading at Portage on March 22 was 0.1 of a foot above zero. No opportunity has since presented itself to examine this portion again at low-water.

On June 17, during the freshet, when the elevation of the surface of the river was at 7 feet above zero at Portage, soundings were taken in the channel for a distance of half a mile in front of Portage. The least depth found was 11.2 feet, and the greatest exceeded 13 feet, the length of the sounding-pole.

3. GAUGING RIVER.

The river was gauged several times between Portage and Dekorra in September and October, and once at Kilbourn City in November.

Water gauges were established in March at Dekorra and Merrimack, and observations of the same made from and after the time the ice went out.

In previous annual reports it has been stated that the zero of the gauge at Portage was at the elevation of the low-water of 1872. This information was obtained from a platted gauge record, began previous to 1874 and continued thereafter. An examination of all the original records made last fall disclosed the fact that the reference of the zero of the gauge is 0.45 of a foot above the low-water of 1872, where it has remained ever since that year.

The zeros of the three gauges above mentioned have not yet been referred to the same datum line.

4. SNAGS AND LEANING TREES.

Two hundred and twenty-nine snags and 1,176 leaning trees were removed from the channel between Portage and Prairie du Sac. It would be well hereafter to use the water-jet process in removing snags.

5. BOATS.

All the boats are in excellent condition, except one of the quarter boats, which has no hull.

The tug Winneconne was thoroughly repaired last winter; a Howe truss was run through her hull from stem to stern. She formerly drew 28 inches; her present draught is 22 inches.

The stern-wheel scows Boscobel and Dekorra were rebuilt last winter. They are now finely-modeled side-wheel tugs as well as scows. They are both alike; each has two Howe trusses through the hull from stem to stern, is 80 feet by 18 feet, and draws 16.5 inches on even keel when light. These boats are very serviceable. A new deck was built on one small scow.

This river suffered from the drought last fall in common with the Ohio and other rivers. The water was so low that the fleet could not be run to a tributary to winter, as usual. It passed the winter safely below the island between dams Nos. 3 and 4, 1879, near Prairie du Sac.

6. MATS.

All mats are now made 13 by 4 feet by 8 inches, as nearly as possible. Each is composed of six fascines. They will vary in weight from 270 to 500 pounds, depending on their age, and also on the kind and size of the brush of which they are composed. After they have been borne from the bank at a mat-yard to a mat-scow they require but little carrying, for in building the greater part of a slant the mat-scow is placed across the up-stream end of the stone scow, so that two men can throw the mats into the water and a third guide them into position with the aid of a mat-hook and the current. In building the main dam and spur the same thing is accomplished by allowing the mat-scow to project beyond the side of the stone-scow above it. This plan greatly facilitates the work, as formerly mats were carried over the stone-scow in most cases.

A comparison of the present system of making mats from fascines was made with the plan of making them of loose brush used in building one dam in the Arkansas River at Fort Smith, Ark., described on page 659 Report of the Chief of Engineers, 1878. In making mats according to the latter plan a rigid mat frame, light and portable, was used instead of the one described in the said report, but of the same general dimensions. It resembled a wagon-rack for cord wood.

Mats were made both ways of the same kind of brush, in the same locality, and weighed the same day the brush was cut down. Those composed of fascines, made larger than usual purposely, were 13 by 4.5 feet by 9 inches, and those of loose brush were of the same size except that they were 1 foot in thickness instead of 9 inches. One of the former weighed 410 pounds and one of the latter weighed 335 pounds, a difference of 75 pounds in favor of the former, the same size as the latter except that the latter was 3 inches thicker; it could not have been compressed any more with the binders.

The mats of loose brush did not well withstand handling, not only in building a dam, but in transporting them. Often one pair of binders and occasionally both pairs came off, as the mats were so loose. This was a very objectionable feature, especially when working in deep, swift water, where a number were lost. This rarely happens with the mat made of fascines.

Where many mats are required, and they are to be made of loose brush, it is hardly possible to get a great number in one place. If they be made very far from a landing, four men and a driver are required to load them on to a wagon with some difficulty, and the same unload them. If they have to be carried by hand, say 100 feet, much hard labor is also required. The cost of the mats of loose brush in the dam is greater than that of those made of fascines. All of which shows a decided difference in favor of the latter.

7. THE JUNE RISE.

The greater rise in this river at Portage from 1872 (inclusive) to last month occurred on May 3, 1876, at which time the gauge reading at Portage was 6.3 feet above zero. This rise was exceeded last month, the elevation of the surface of the river being at noon on June 17, 7.1 feet above the zero of the Portage gauge. There are those who claim that the river had been higher before, but the majority of the oldest inhabitants of Portage with whom I have conversed on the subject affirm that there has been none to equal it.

It rained a great deal all along the river for several days previous to the rise. The flood covered nearly all the bottom lands between Portage and the Baraboo River. The portage part of the Portage and Caledonia causeway across the bottom lands was covered with water averaging 2 feet in depth for a considerable distance; this portion of the causway has five openings in it exclusive of the five spans in the bridge over the main river for the discharge of water; not so with the Caledonia portion, where there is but one small opening through it a short distance from the Baraboo River, through which some water discharged into said river during the late rise. The freshet did, however, make another opening through it on June 12 about half a mile from the Baraboo Bluff, 150 feet wide and 3 feet in depth; even then there was 1 foot head against the causeway, and a strong current swept along it on the upper side. Immediately after this break (June 12) the water fell a little at Portage. Ample openings should be made in this part of the causeway to discharge the river through it as formerly at freshet stage.

On June 15 the river broke through the two Lewiston levees about 3 miles above Portage on the left bank, and discharged a portion of its water into Big Slough; thence into Neenah Creek, and thence into the Fox River just above Governor's Bend lock, washing out a portion of the track of the La Crosse division of the Chicago, Milwaukee and Saint Paul Railroad Company, and also several wagon-road bridges.

These levees were built about 1866, and some work has been done on them since from time to time. The lower one was not very strong nor very high the day that I inspected it—the day that it broke. I understand that sand entered very largely into their composition. If rebuilt, they should certainly not be made higher than formerly, if as high, as they obstruct the natural flow of the water at freshet stage, and help to send more water below than can well be taken care of, except at some expense.

No great trouble was experienced at the Portage City (guard) Lock; it could have withstood a greater rise with flush boards on the gates.

After the freshet was over it was found that the high-water had developed a leak under the lower miter-sill. This is now being stopped with two rows of sheet piles across the lock above and below the sill, and a concrete wall between them. It is believed that this lock is well located, and that the canal revetment should be completed of timber and piles on the south side below it.

The Portage authorities threw up a levee about 2 feet in height along that part of Wisconsin street lying in the first ward; this was protected in a measure by the stone and mat piles belonging to the United States. Some of the levee was faced with brush mats. Fortunately, there was but little wind and no break occurred at Portage.

The water, however, did back up into Swan Lake through Duck Creek, and also broke over the "plank road" below the Portage toll-gate (on June 16), covering the flats in the first ward of Portage a little with backwater, and washing out portions of the La Crosse and Madison divisions of the Chicago, Milwaukee and Saint Paul Railroad Company in its course to the Fox River. The northern division of the said company was flooded in places, but not obstructed. The Wisconsin Central Railroad track was also flooded and obstructed for some days between Portage and Packwaukee.

The Fox River rose very rapidly, and backed up into the Portage Canal through the waste-weir. A low levee, faced with stone, was thrown up on each side of the upper gates of Fort Winnebago Lock to check an overflow as soon as the canal would be filled. The least head on the upper gates of this lock during the freshet was 0.5 of a foot.

Fortunately, the Lewiston lévees broke above Portage before the "plank road" below was overflowed, so that the water from the former could back up and raise the Montello level, and the two floods could about equalize the levels at Governor's Bend Dam, and do no great damage there. As soon as the levels were at the same height (on June 18) all of Governor's Bend Lock gates were opened and loaded with stone, which was required to prevent them from floating out.

The highest water at this point was on June 20; the lock was nearly covered with water, the top timbers of the rear walls and some of the ties and the coping of the front walls were raised up by the water but have settled back into place again.

The lock is in very poor condition above low-water. The least depth of water on the lower miter sill is 4.4 feet at low-water. This sill could be cut down and the lock repaired the same as the Portage City (guard) Lock, after which it would probably suffice for some years. By feeding and flooding, a boat drawing 5 feet of water could almost always be passed through it.

No great damage was done to the improvement works by the freshet, except the washing of the dredge banks in a slight measure, which formed small bars; of course the new banks suffered the most. The Fox River Valley was well filled with water; all marshes not covered were well soaked. As soon as it was known that the Fox would be flooded notice was sent to the Montello and Grand River lock tenders to prepare for it.

The appended records of water gauges for last month at Portage City, Fort Winnebago, and Governor's Bend locks will show the various stages of the water at those points during the freshet.

8. PERSONAL.

Mr. Ed. C. Hinman rendered efficient services in the prosecution of the foregoing operations.

SUMMARY STATEMENT OF WORK DONE DURING THE YEAR.

	Linear feet.
Built five dams	4,625
Extended four dams	2,050
Extended one bank protection	224

Pulled 229 snags.

Felled 1,176 leaning trees.

Repaired and maintained the work between Portage, Wisconsin, and Wild Cat Bluff, as above stated.

Repaired and constructed boats, implements, &c., as required.

Very respectfully, your obedient servant,

F. A. HINMAN,
First Lieutenant, Corps of Engineers.

Maj. D. C. HOUSTON,
Corps of Engineers.

NOTE.—The lists of soundings referred to as appended to this report are omitted.—D. C. H.

MESSRS. M. H. KEYSAR & COMPANY TO MAJOR D. C. HOUSTON, CORPS OF ENGINEERS.

PRAIRIE DU SAC, WIS., *July* 28, 1879.

SIR: We shall be unable to run our boat during the balance of this season unless we get a permanent rise of water, or some work is done in the vicinity of this town; we have had plenty of trouble all the season at this place.

The place that troubles us is opposite the head of Long Island just above the dam put in by Mr. Nader, six years ago. Mr. Hinman can tell you where it is, and the shape the river is in.

We have got the largest crop of grain in this vicinity we have ever raised. It seems too bad if we are not able to handle it owing to the one poor place. Can you do anything to fix it immediately?

Please let us hear from you.

Yours, truly,

M. H. KEYSAR & CO.

Col. D. C. HOUSTON.

Record of water gauges at Portage City Lock, Wisconsin, during the month of June, 1880.

[Elevation of zero upper gauge, 3.2 feet above upper miter sill. Elevation zero lower gauge, 0.33 foot above lower miter sill. The difference in elevation of the two zeros is 0.33 of a foot. The readings are in feet and tenths.]

Date.	Upper gauge.		Lower gauge.		Date.	Upper gauge.		Lower gauge.	
	7 a. m.	6 p. m.	7 a. m.	6 p. m.		7 a. m.	6 p. m.	7 a. m.	6 p. m.
June 1	0+1.7	0+1.7	Water out of canal.		June 16	0+6.85	0+6.95	2.75	2.75
2	0+1.65	0+1.65	Do.		17	0+7.0	0+7.5	2.75	2.75
3	0+1.6	0+1.55	Do.		18	0+7.0	0+6.95	2.8	3.3
4	0+1.7	0+1.7	2.4	2.6	19	0+6.9	0+6.8	3.4	3.85
5	0+1.65	0+1.7	2.6	2.6	20	0+6.7	0+6.6	3.85	3.8
6	0+1.65	0+1.7	2.6	2.6	21	0+6.5	0+6.4	3.6	3.4
7	0+1.8	0+2.1	2.65	2.6	22	0+6.2	0+5.95	3.2	2.8
8	0+2.3	0+2.9	2.65	2.5	23	0+5.65	0+5.3	2.45	2.3
9	0+3.8	0+4.4	2.65	2.6	24	0+4.9	0+4.6	1.7	1.4
10	0+4.8	0+5.3	2.6	2.5	25	0+4.35	0+4.1	0.9	0.4
11	0+5.8	0+6.2	2.7	2.5	26	0+3.95	0+3.75	Water out of canal.	
12	0+6.55	0+6.6	2.5	2.5	27	0+3.6	0+3.5	Do.	
13	0+6.5	0+6.4	2.55	2.6	28	0+3.35	0+3.2	Do.	
14	0+6.3	0+6.3	2.6	2.8	29	0+3.1	0+3.0	Do.	
15	0+6.35	0+6.6	2.7	2.75	30	0+2.9	0+2.9	Do.	

Commenced letting water into the canal on the 3d. From the 4th to the 11th fed one valve. The highest water in the Wisconsin River occurred at noon on the 17th, at which time the upper gauge reading was 7.1 feet above zero.

WILLIAM EDWARDS,
Lock Tender.

Record of water gauges at Fort Winnebago Lock, Wisconsin, during the month of June, 1880.

[Elevation of zero upper gauge on upper miter sill. Elevation zero lower gauge on lower miter sill. The zero of upper gauge is 2 feet above that of lower gauge. The readings are in feet and tenths.]

Date.	Upper gauge.		Lower gauge.		Date.	Upper gauge.		Lower gauge.	
	7 a. m.	6 p. m.	7 a. m.	6 p. m.		7 a. m.	6 p. m.	7 a. m.	6 p. m.
June 1	Water out of canal		5.85	5.8	June 16	10.5	10.5	6.75	6.7
2	.........do.........		5.6	5.6	17	10.5	10.5	7	9.5
3	.........do.........		5.7	5.65	18	10.6	11.1	11.45	12.2
4	10.2	10.4	5.8	6	19	11.15	11.6	12.65	12.70
5	10.4	10.4	6.3	6.5	20	11.6	11.55	12.81	12.79
6	10.4	10.4	6.5	6.65	21	11.4	11.2	12.55	12.3
7	10.45	10.4	6.55	6.45	22	11.0	10.6	12.0	11.7
8	10.4	10.3	6.5	6.6	23	10.25	10.1	11.25	10.9
9	10.45	10.4	6.7	6.6	24	9.5	9.2	10.3	9.9
10	10.4	10.3	6.5	6.5	25	8.6	8.4	9.3	9
11	10.5	10.3	6.7	6.5	26	Water out of canal		8.5	8.1
12	10.3	10.3	6.45	6.4	27	.........do.........		7.6	7.3
13	10.4	10.4	6.5	6.5	28	.........do.........		7.1	6.9
14	10.4	10.5	6.5	6.7	29	.........do.........		6.9	6.9
15	10.5	10.55	6.75	6.8	30	.........do.........		6.75	6.6

The least head of water on the upper gates was 6 inches.

WILLIAM EDWARDS,
Lock Tender.

Record of water gauges at Governor's Bend Lock, Wisconsin, during the month of June, 1880.

[Elevation of zero upper gauge on upper miter sill. Elevation zero lower gauge on lower miter sill. The difference in elevation of the two zeros is 1.6 feet. The readings are in feet and tenths.]

Date.	Upper gauge.		Lower gauge.		Date.	Upper gauge.		Lower gauge.	
	7 a. m.	6 p. m.	7 a. m.	6 p. m.		7 a. m.	6 p. m.	7 a. m.	6 p. m.
June 1	7.4	7.2	5.9	5.8	June 16	7.5	7.5	6.8	6.8
2	7.1	7.1	5.7	5.7	17	7.4	8	6.8	7.3
3	7.2	7.2	5.8	5.8	18	8.8	10.9	8.3	12.6
4	7.2	7.3	5.8	5.9	19	12.2	12.35	13.4	13.95
5	7.4	7.5	6	6.3	20	12.55	12.55	14.2	14.25
6	7.6	7.6	6.4	6.5	21	12.4	12.15	14.05	13.75
7	7.6	7.6	6.6	6.6	22	11.8	11.4	13.45	13.05
8	7.6	7.6	6.6	6.6	23	11	10.55	12.6	12.15
9	7.6	7.6	6.7	6.7	24	10.1	9.75	11.75	11.4
10	7.5	7.5	6.7	6.7	25	9.35	9.05	11	10.65
11	7.5	7.5	6.7	6.7	26	8.7	8.35	10.35	10
12	7.4	7.4	6.6	6.6	27	8.05	7.75	9.65	9.35
13	7.4	7.4	6.6	6.6	28	7.5	7.75	9.1	8.7
14	7.4	7.4	6.6	6.8	29	7.8	7.8	8.4	8.2
15	7.4	7.4	6.8	6.8	30	7.7	7.6	7.9	7.6

All the gates were opened the 18th and remained open until the 28th, when they were closed.

RICHARD E. RICE,
Lock Tender.

FOX RIVER.

REPORT OF LIEUTENANT F. A. HINMAN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., July 1, 1880.

SIR: I have the honor to submit the following report of operations on that part of the Fox River improvement under my charge for the fiscal year ending June 30, 1880.

1. PORTAGE CITY (GUARD) LOCK.

After the close of navigation last fall, a coffer-dam was thrown across the upper approach to this lock and the lock drained by drawing down the Portage Canal, so that no pumping would be required in repairing it. This lock, which had never been thoroughly repaired since it came into the possession of the United States, was found to be in a very dilapidated condition; it was ascertained that at some time it had been lengthened 21 feet, the original lower gate recesses being built out with framing. The present dimensions of the lock are 160 by 35 feet.

The recent repairs have placed it in excellent condition. They were as follows: The coping and upper seven courses of timber of the lock walls were replaced by new ones, and new diagonal braces were put into the walls to support the rear courses. The upper wing-walls that formerly stood on props above the floor were built anew and placed directly on the floor. Mortises were cut in them to provide for future coffer-dams. The upper nine courses of the lower wing-walls were renewed, and all the walls were refilled with sand. New hollow quoins and gates, with the exception of the old iron valves, were built. Sheet piles were driven across the walls at the upper ends of the upper wing-walls, and also at the upper hollow quoins. The old balance-beams were discarded, and the new style of gate-hangings put on and well secured, not only to the walls but to anchorages beyond. The gates are operated by new rack and pinion attachments. In the upper gates waste-weirs were so constituted that the Portage Canal can be fed from the surface of the Wisconsin River at all stages above low-water, instead of from the bottom (through the valves) as heretofore. It is believed that this will serve to lessen the amount of sand that is drawn into the lock. The waste-weir in each gate consists of loose vertical planks rabbeted into the upper arm and the first arm above the valves, which can be quickly removed, or replaced by hand when the pressure is off the gate; the upper rabbet, assisted by two iron cross-bars, the top one of which is locked, holds them in place when the pressure is off and prevents their removal except at will. The lock was lined anew throughout

with two courses of plank 1 inch and 2 inches thick, respectively. The lock chamber was cleaned out, and the entire floor repaired, battened and cross timbers put on to bind it well. The upper miter-sill was not disturbed except to repair it; it can be easily cut down 4 inches when ordered; the lower miter-sill, which was the same height as the upper miter-sill, was cut down 4 inches, in order that there may always be a depth of 3.5 feet of water on it when the stage of water in the Wisconsin River will admit of it. The least depth on the upper miter-sill since 1872 (inclusive) is 2.4 feet (in 1877), and the greatest depth 10.3 feet (during last month).

Six snubbing-posts were placed.

On completion of the above repairs the coffer-dam was removed by dredge No. 2, and the canal filled the fore part of April.

2. PORTAGE CANAL.

Dredge No. 2 removed an approximate estimate of 665 cubic yards of material from the upper approach to the Portage City (Guard) Lock, which had filled up but slightly, making it deeper for future contingencies, and wider.

A fender of piles, capped with one course of timber, was constructed on each side of this approach from the lock to the river. The one on the north side is 134 feet long and that on the south side is 120 feet in length; the east 117 feet of the former, and also the east 67 feet of the latter, next to the lock, were sheet piled, in order to form a revetment to keep out the sand. Eight snubbing-posts were driven on the north side of this approach above the fender.

Dredge No. 2 removed 478 cubic yards of material, estimated approximately, from the canal at Wisconsin street bridge, the most of which had been deposited there when the bridge was rebuilt, the balance having been washed in.

Last year the canal was widened just below the Portage City (Guard) Lock so that boats 95 feet long could turn there. In so doing the brush and stone revetment was removed. The consequence was that the bank was eroded at this point, and a small bar containing 133 cubic yards of sand formed near it. It was removed by hand while the canal was empty, and the bank again reveted.

Two spring piles were driven at the lower railroad bridge to facilitate the passage of boats through it, and twenty-five snubbing-posts were driven at convenient places along the canal.

This spring the city of Portage replaced the float-bridge at Ketchum's Point by an iron swing draw-bridge with stone substructure, having a clear water-way of 60 feet perpendicular to the axis of the canal when the draw is open. It is protected by piles.

The honorable the Attorney-General of the United States gave an opinion, dated February 21, last, that "the United States are not under any liability to maintain the draw-bridge across the Portage Canal" at Wisconsin street.

3. FORT WINNEBAGO RESERVATION.

The boundary lines of this reservation were rerun, and the reservation fenced in. It lies on the north side of the Fox River at Fort Winnebago Lock, and is about equally divided by the Portage Canal; it contains 22.28 acres. The buildings thereon not belonging to the United States, with one exception, were removed by their owners.

4. GOVERNOR'S BEND LEVEL.

On the close of navigation last fall this level was drawn down in order to repair Governor's Bend Dam, after which it was raised; during this time the breast-wall at the upper end of the level prevented the reformation of a bar below it.

Dredge No. 2 cut off two small points on this level on the left bank a short distance below Fort Winnebago Lock; the estimated amount of material removed was 850 cubic yards.

5. GOVERNOR'S BEND LOCK.

This lock received minor repairs from time to time; it is not in very good condition and may require extensive repairs before long. A new lock should be substituted for it.

6. GOVERNOR'S BEND DAM.

This dam was thoroughly repaired as follows: The abutments and breast slope were replaced by new ones of a similar description; leaks were stopped in the back slope; sheet piles were driven along and adjacent to the upper side of the dam, and the abutments filled and surmounted with clay principally.

7. MISCELLANEOUS.

The Fox River was fed from the Wisconsin River as required.

During last month a freshet occurred in the Wisconsin River, which broke through the left bank into the Fox River. A description of this freshet will be found in my annual report of operations on the Wisconsin River improvement for this fiscal year.

The hull and boiler flues of the floating pile-driver were recaulked.

Mr. Ed. C. Hinman rendered valuable services in the prosecution of the foregoing operations.

Very respectfully, your obedient servant,

F. A. HINMAN,
First Lieutenant, Corps of Engineers, U. S. A.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

REPORT OF MR. C. A. FULLER, ASSISTANT ENGINEER.

APPLETON, WIS., *July* 1, 1880.

SIR: I have the honor to submit the following report of operations on the improvement of the Lower Fox River for the fiscal year ending June 30, 1880:

No new works were commenced during the year; operations were confined to the continuance of works already commenced, to quarrying, dressing, and transporting stone, and to repairs of locks, dams, and canal banks.

Navigation was continued without interruption until closed by ice on the 30th of November. Necessary repairs to the locks having been made during the winter and early spring months, navigation was resumed throughout the line on the 8th of May, and has continued uninterruptedly to the present time. The following outline of operations at each point on the Lower Fox River is respectfully submitted.

1. DUCK CREEK QUARRY.

Quarrying stone was continued at this point until September 30, 1879, at which date work was suspended, and has not since been resumed. During the short working season there were taken out and hauled to the stone-yard 221 cords of dimension stone and 103.2 cords of large backing stone; 2,136 cubic yards of earth were stripped and removed from the quarry. Stone-cutting has been continued during the whole year. There has been dressed, for revetment wall of Appleton Canal, 4,902 superficial feet, pitched faced; 2,070 superficial feet of pointed faced; 1,015 superficial feet, bush-hammer dressed, and seven arches (2,891 superficial feet) for flumes; 6,571 superficial feet of ashler, 32 round corners and check-stones, and 31 hollow quoins were bush-hammer dressed for construction of new lock.

2. DE PERE LOCK (OLD).

The west upper wing-wall was raised 1 foot, new spars placed on gates, and slight repairs made to the lock.

3. DE PERE DAM (NEW).

A coffer dam 80 by 15 by 8 feet was framed, planked, and sunk at west end of dam, and the foundation prepared for the connecting crib; one crib was framed and bolted, and the connecting cribs at each end of the dam were sunk in position and filled with stone. The crest timbers, stringers, and planking of dam were finished, and bulkheads built at each flume. The canal bank between east abutment and head of lock was strengthened and raised from 12 to 24 inches. The dam is completed, with exception of flanking the flumes, eight in number, and finishing the clay and gravel backing. Work was suspended on the 25th of November, the property inventoried and stored, and the force discharged.

Twenty-seven hundred and eighty-five linear feet of crest timbers and 2,096 linear feet of stringers were framed and bolted, and 1,994 linear feet of dam planked during the working season.

4. LITTLE KAUKAUNA DAM (NEW).

Slight repairs were made to abutment of south end of the dam.

5. LITTLE KAUKAUNA LOCK (OLD).

New spars were put on gates and slight repairs made.

6. RAPID CROCHE DAM (NEW).

Slight repairs were made to abutments at each end of dam.

7. RAPID CROCHE LOCK (OLD).

Repairs were made to head walls and to canal bank adjacent to the lock; new spars were put on gates and suspension rod repaired.

8. KAUKAUNA QUARRY.

Four hundred and seventy-four and forty-seven hundredths cords of dimension and backing stone were quarried and hauled to stone-yard, and 4,232 cubic yards of earth stripping removed. Quarrying was suspended on September 30, and the pump, engine, and tools removed and stored. The following stone have been dressed during the year, viz: For revetment wall of Appleton Canal, 1,793 superficial feet, pitched faced; for new lock at Little Chute, 1,617 superficial feet for chamber and recess walls, 2,790.54 superficial feet of coping stone, 159.4 linear feet of round corners (3 feet radius), and 91.4 linear feet of hollow quoins, all bush-hammer dressed; for new lock at Kaukauna, 56 corner and check stones, sixty hollow quoins, and 8,322 superficial feet for walls. Dressing stone at this work is suspended.

9. KAUKAUNA DAM (NEW).

Slight repairs were made to the embankments at each abutment.

10. KAUKAUNA 5TH LOCK (OLD).

Two new spars were put on gates and slight repairs made.

11. KAUKAUNA 4TH LOCK (NEW).

The capstan platforms were leveled up and repairs to banks adjacent to head walls made.

12. KAUKAUNA 2D LOCK (OLD).

Portions of chamber walls were replanked, the coping of walls repaired, new spars put on gates, six snubbing posts set, and capstan platforms repaired.

13. KAUKAUNA 1ST LOCK (OLD).

The coping of walls was repaired, seven snubbing posts set, chamber walls partly replanked, and capstan platforms repaired.

14. LITTLE CHUTE COMBINED LOCKS (NEW).

Two oak paddle arms were placed in middle gates and a new bumper to upper platform put on; one new maneuvering gear for upper platform valves was placed and the valve chains on platform replaced by iron rods.

15. LITTLE CHUTE 2D LOCK (OLD).

Two new diamond blocks and one new iron capstan were placed, two new spars put in gates, and the south wall replanked.

16. LITTLE CHUTE LOCK (NEW).

This lock is to replace the 1st and 2d Little Chute locks. The height of walls is 25.5 feet above the lower miter sill and the lift 15 feet. During the year the excavations for lock pit and for inlet and outlet have been completed, requiring the re-

moval of 1,396 cubic yards of rock and 4,885 cubic yards of earth and spals. A dry wall, extending from lower end of south wall of lock, containing 47 cubic yards, was built, and from the upper end a wall was constructed, containing 133 cubic yards of cement masonry. The slopes of both inlets, 2,374 superficial feet, were paved with stone. The lock walls, measuring 3,202 cubic yards, were laid in cement mortar, and the joints pointed. A miter-sill platform and two miter sills were framed and bolted in place; lock gates were constructed and hung; gate and recess valves placed, and fifteen steps built at lower end of lock; 350 cubic yards of clay filling were placed in rear of south wall and 2,270 cubic yards on canal banks; the coffer-dams were removed and the lock and canal levels cleaned up. This lock is completed. To finish the work at this point a head wall across the old 2d lock will be built and the walls of the 1st lock raised to the level of those of the new lock. The stone used in construction was received from Kaukauna quarry. During the year 2,141 barrels cement, 459 cubic yards sand, and 663 bushels of lime were purchased in open market and expended.

17. LITTLE CHUTE 1ST LOCK (OLD).

One new iron capstan was placed, the coping repaired, and slight repairs made to the gates.

18. LITTLE CHUTE DAM (NEW).

Slight repairs were made to the embankments at each abutment.

19. CEDAR'S DAM (NEW).

No repairs were made to this dam during the year.

20. CEDAR'S LOCK (OLD).

In November, 1879, one of the lower wing-walls of this lock fell in, obstructing navigation at this point four days. A crib wall was built to replace it, and the *débris* of the old wall was removed. Repairs were commenced in January, 1880; coffer-dams were put in above and below the lock, and an engine and centrifugal pump was constantly worked to keep the lock free from water; two new lower wing-walls were constructed; two lower hollow quoins made and secured in place; one new gate built and hung; the old planking stripped where found necessary, and replaced by new; new coping was placed the whole length of the south wall, and for a length of 75 feet on the north wall; eleven anchor-bolts, two diamond blocks, and one snubbing post were placed and secured. The coffer-dams were removed, and pump, engine, and tools stored; 4,171 feet, b. m., oak timber; 11,686 feet, b. m., pine timber and plank were purchased and expended.

21. APPLETON 4TH LOCK (OLD).

The lower gates were taken out, the hollow quoins cut off at surface of water, and replaced by new ones; 6 cubic yards of dry wall in rear of hollow quoins was taken down and cement masonry built in its place; eight new posts were placed in chamber walls, and a new coping laid on the south wall; one snubbing post put in, and the walls planked where found necessary.

22. APPLETON LOWER DAM (OLD).

Slight repairs were made to the timber abutment of the south end of the dam, and to the embankment.

23. APPLETON 3D LOCK (OLD).

Repairs to this lock were commenced in January, 1880, coffer-dams were built above and below, and an engine and pump constantly worked. The old gates, hollow quoins, and miter sills were removed; 35 cubic yards of loose rock were removed from under the miter sills; masonry walls and bed timber were laid to support the miter sills; new miter sills were framed and bolted in place; new hollow quoins were made and secured in place, and gates repaired and rehung. Both walls were partially planked, and new coping put on; thirteen anchor-bolts were placed in chamber walls; new capstan platforms were made at lower end and the upper ones replanked; five snubbing-posts were put in; 336 cubic yards of old lower wing-wall were taken down and 90 cubic yards of clay removed from under one wall; 218 cubic yards cement masonry were laid in lower wing-wall, and under miter sills, and 36 cubic yards of dry stone

wall built in extension of wing-wall; 310 cubic yards of mud and gravel were taken from lock-pit and from between wing-walls. The engines and pumps were removed and stored; 7,857 feet, board measure, oak timber, 9,839 feet, board measure, pine timber, and 14,446 feet, pine plank and boards, 144 barrels of cement, and 80 bushels lime were purchased in open market and expended.

24. APPLETON 1ST LOCK (OLD).

The lower gates were removed, the wall in rear of hollow quoins relaid, and the gates rehung. A new coping for the north wall was framed and placed, sixteen new upper posts put in, and the lower south-wing walls rebuilt.

25. APPLETON WASTE WEIR.

A weir 22 feet in the clear, to regulate the water in the Appleton 3d level, was constructed in left bank of the canal near the 3d lock; 377 cubic yards of earth were excavated; 10,127 feet, board measure, pine timber, framed and bolted in place; 11 cords rubble-stone filling put in, and the sides and apron sheathed with pine plank.

26. REVETMENT WALL OF APPLETON CANAL.

The work of construction was continued on this wall to the 22d of November, 1879, on which date it was suspended for the season, and the engine, pump, and tools removed and stored. During the working season coffer-dams were built, water pumped out, foundations leveled, and 3,645 cubic yards of cement masonry laid, and a dry stone wall containing 12 cubic yards built in rear of head wall of Appleton 1st lock; 1,416 barrels of cement, 377 bushels of common lime, and 377 cubic yards of sand were purchased and expended on the work. Stone used in construction was brought from Duck Creek and Kaukauna quarries, and from Little Chute. The length of wall completed to level of bottom of coping is 548 feet. Average height above rock foundation is 20.6 feet; 118 linear feet of wall in continuation is built up to within 5 feet of the bottom of coping, the average height being 12.1 feet. To complete the work 118 linear feet is to be built 5 feet in height, and 126 linear feet to a height of 14.5 feet, and a stone coping 6.5 feet wide by 1 foot thick laid the whole length of the wall.

28. MENASHA LOCK (OLD).

The west upper wing wall was planked; one new diamond block and three snubbing-posts placed and secured; gates repaired and two new spars put on.

29. REPAIRS TO BREAK IN MENASHA CANAL BANK.

A serious break occurred in the canal bank at Menasha on the 18th of April, 1880, caused by a severe gale from the southwest, forcing the water of the lake into the canal. The bank of the basin on the west side of the lock was washed out for a length of about 100 feet down to the level of the bottom of the canal. A coffer-dam 125 feet long and 8 feet high was built across the canal as soon as possible, the water drawn off, and repairs of bank pushed vigorously. The breach was filled to the level of the old embankment, and other portions of the bank were raised and strengthened. The coffer-dam was removed and navigation opened on the 8th of May; 3,113 cubic yards of clay and 59 cords of rubble stone were required to make the repairs. There was expended in the construction of the coffer-dam 10,712 feet, board measure, pine timber and plank, 3,357 feet, board measure, long timber, 5,864 feet, board measure, of hemlock, and 15.5 cords stone.

30. DREDGING.

Dredge No. 1, after removing loose rock and bowlders from the channel of the river above Appleton, proceeded to Duck Creek and deepened its channel, so as to permit the passage of boats transporting stone from the quarry, removing 8,666 cubic yards of sand and clay. On completion of this work the boat returned to De-Pere, removed the abutments of an old bridge across canal basin, and excavated a channel 60 feet in width to bed rock through the basin to the head of the lock, then proceeded to Little Chute and removed 1,476 cubic yards of earth and spalls from the 3d level of the canal; from thence to Menasha, and removed bowlders and oak logs from the river channel; then returned to Cedars Lock, removed portions of the old wing-wall that had fallen in; thence proceeded to Appleton, removed three old cribs from above the stone dam and was towed to Kaukauna, laid up for the season, and the crew discharged on the

22d of November. Repairs having been made to boat and machinery during the spring months, the dredge, prior to resumption of navigation, removed the coffer-dams at Little Chute, Cedars, and Appleton 3d locks, and from Menasha Canal, and has since been employed in dredging the 2d and 3d levels of Appleton Canal.

No. 7, Clam Shell Dredge. This dredge was purchased and received at De-Pere on the 22d November, 1879. After fitting up the machinery, it was towed to Duck Creek by the steamer Neenah for trial. Having widened the cut made by Dredge No. 1, and deepened the water at the quarry landing, it was then towed to Kaukauna by the Neenah, where both boats were laid up and their crews discharged.

31. MISCELLANEOUS.

One hundred and eighty-five cubic yards of clay were placed on bank of 5th level of Kaukauna Canal and 59 cubic yards of rubble stone were hauled and placed on its exterior slope. Slight repairs were made to canal bank near Appleton 4th, Rapid Croche, and Little Kaukauna locks.

The steamers Henrietta, Neenah, and steam launch General Meade with scows were employed in transporting materials for the works in progress.

All of the old wooden locks are in bad condition, requiring constant repairs to keep them in working order, and should be replaced by stone ones. The lock at Rapid Croche, the only one built of stone by the old company, is in fair condition, but will have to be lengthened 10 feet between hollow quoins to correspond in length to the new locks. When replaced, I would respectfully suggest that the new ones be constructed in the following order, viz: Menasha, Appleton 1st, Kaukauna 1st, Appleton 3d, Kaukauna 2d, Appleton 4th, Cedars, Little Kaukauna, Kaukauna 5th, and De Pere.

Stone for the first-named three locks has been quarried, dressed, and for the Menasha lock is being transported from Duck Creek quarry to Menasha by the steamers Henrietta and Neenah.

Very respectfully, your obedient servant,

C. A. FULLER,
Assistant Engineer.

Maj. D. C. HOUSTON,
Corps of Engineers, U. S. A.

D D 6.

EXAMINATION OF OCONTO RIVER, WISCONSIN.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., October 30, 1879.

GENERAL: I have the honor to transmit herewith a report by Mr. W. H. Hearding, assistant engineer, on an examination of Oconto River, Wisconsin, made in pursuance of the act of Congress making appropriations for rivers and harbors approved March 3, 1879.

A survey of the mouth of Oconto River, with estimates for its improvement up to the city of Oconto, was made in 1870 and submitted with my report, dated December 17, 1870. (See Report of Chief of Engineers for 1871, page 120.) No resurvey has been deemed necessary, but the estimates can be greatly reduced, owing to the reduced cost of labor and materials, and by modifying the plan of improvement.

The plan of improvement is indicated on the accompanying tracing, and consists of two piers at the mouth of the river and dredging the channel up to the city, including the cut-off marked in red, C. D.

This cut-off shortens the river so much that its cost will not be greater than dredging the river itself, besides giving a much better route for vessels.

The piers are made only 16 feet wide, instead of 20 feet, as originally

designed, and the width of channel in the river is reduced from 200 to 150 feet.

This width of pier (16 feet) is deemed sufficient for this locality, where the exposure is much less than in Lake Michigan, and a width of channel of 150 feet is sufficient for the requirements of navigation.

The work should be done in the following order: First, the construction of the north pier, and dredging the bar at the mouth so that vessels can enter the river and receive their cargoes. (Now vessels have to receive their cargoes in the bay.) It is possible that the south pier may not be needed, but that the north pier will protect the channel from prevailing winds. Provision is made, however, for the south pier in the estimates.

Having secured the required depth of water at the mouth, the channel should be dredged up to the city.

Provision is made for dredging to a depth of 12 feet where the piers are to be placed. The total estimate for this work for a complete improvement is $382,027.18. A much smaller sum could, however, be applied with great benefit to the commerce of the place. It is probable that the south pier may be dispensed with or reduced in length. The width of the channel need not, at first, be made as great as estimated for.

When it is considered that the distance from the city to the river mouth, where continuous dredging is required, is over two miles, and that the distance from the river mouth to the 13-foot curve in the bay is nearly 3,000 feet, through which a channel must be dredged and protected by piers, it will be evident the work is one of considerable magnitude. The amount of dredging alone to obtain a channel above the mouth 150 feet wide and 12 feet deep, and in the bay 200 feet wide and of the same depth, is over 800,000 cubic yards.

General Order No. 2, headquarters Corps of Engineers, dated March 15, 1879, calls for, as required by law, "full statements of all existing facts tending to show to what extent the general commerce of the country will be promoted by the several works of improvement contemplated by such examinations and surveys, to the end that public moneys shall not be applied excepting where such improvements shall tend to subserve the general commercial and navigation interests of the United States." (Joint resolution of Congress of July 27, 1867.) Also, "the amount of tonnage or commercial business during the previous year at each point, together with such other facts as bear on the question of the proposed improvement."

The only object sought for in the proposed improvement is to enable large vessels to ascend the river to the city of Oconto. The principal business by vessels is the exportation of lumber. At present the lumber vessels anchor in Green Bay, and the lumber is towed out a distance of about 3 miles in rafts or scows and loaded. The amount of lumber exported, as nearly as can be ascertained, is 80,000,000 feet, one-fifth of which is dressed and shipped by rail, and the remainder, 64,000,000 feet, by water. If the lumber vessels could ascend the river the cost of towing and extra handling would be saved. Estimating the cost of this at 50 cents per thousand, there would result an annual saving of $32,000. It appears, also, that the country in the vicinity of Oconto is rapidly filling up with settlers and that the agricultural productions are rapidly increasing. This will tend to increase the commerce of the place.

If we consider the general commerce of the country as the aggregate of the local commerce arising from exports and imports at the various points on the lakes, rivers, and seaboard, this improvement would be of

general benefit in the proportion of its local to the aggregate commerce of the country.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. H. HEARDING, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Milwaukee, August 12, 1879.

SIR: I have the honor to state that, in obedience to your instructions of the 30th ultimo, I proceeded to Oconto, Wis., on the 6th instant, and made an examination and investigation for the purpose of determining the commercial necessity, practicability, and cost of improving the navigation of the Oconto River from its mouth to the city of Oconto, as specified in your order.

Being furnished with a copy of the map of the detailed survey made under your directions in 1870, no further minute survey is considered necessary for basing an estimate of the quantities of materials required and the amount of excavation needed for such improvement.

I therefore engaged a row-boat and the services of three men and took soundings both down and up the river, from the lower bridge in Oconto to and across the bar at the mouth of the river in Green Bay, Lake Michigan, simply to determine whether any essential changes have taken place in the river since the survey was made in 1870. In going down the river the boat was steered at as uniform a distance of 50 feet from the south bank as practicable, and in returning a similar distance was kept from the north bank. As far as I could determine, no important changes have been effected in the river channel to seriously affect an estimate of the cost of improvement. In the reach immediately below the bridge the water is somewhat shallower than it was at the time of the survey, and the channel at the "Big Bend" has been narrowed through a lodgment of drift-wood, but this latter change would not enter into the cost of improvement, as it is outside of the cut proposed to be made, and even in case the direction of the channel should not be changed from its present tortuous course, the width of the channel has suffered no serious detriment at present from the accumulated drift-wood, for at this point the river must be 180 feet wide from the outer edge of the collected drift to its opposite bank or marsh. From the length of time which the saw-mills upon this river have been in operation, I expected to find the channel obstructed by deposits of sawdust; I, however, did not find many deposits of this character. In a few places it has collected to a small extent, but the general character of the material forming the river bed is sand. In going down and up the river I took 592 soundings, and I found sawdust in only about half a dozen places. During my visit of two days' duration I had occasion to cross the river several times, and noticed the current each time I crossed. The water in the river is much lower than usual, but the outflow was constant and quite rapid during the time of my visit. It is probable, therefore, that most of the sawdust is carried by the current out into Green Bay and deposited upon the beach.

As the wind was constant from the west, I thought it probable that a sudden change in its direction might at times influence the flow of the current, and I inquired of some of the raftsmen whether such was not the case. They replied that there was generally a good current down stream, but it was not unusual for the water in the bay to set back into the river when the wind shifted from westerly to easterly. I found a spike driven into the northeast corner of a crib in the river, which is probably the bench mark described on the map of survey of 1870. This spike was $1\frac{8}{10}$ feet above the water level when I took the soundings in the river on August 6 instant.

Mr. R. L. Hall, county surveyor, has kindly furnished me with data which establishes the identity of the bench mark, and which also shows the water in the river to be $1\frac{6}{10}$ feet lower this year than it was in 1870.

I conferred with a number of the leading citizens interested in the river improvement. They, one and all, are very anxious to obtain the assistance of the United States Government in the construction of a harbor at the mouth of the river and the improvement of the river channel, so that vessels can be brought up to the mills to receive their cargoes without incurring the expense incident to rafting the lumber and square timber from the mills to the anchorage in Green Bay, which is situated at a distance of 5 miles from the lower or nearest mill on the river. There are 6 mills in

operation at the present time, 5 of which are run by steam, and 1 by water power. As near as I can ascertain, the quantity of lumber manufactured at and shipped from this point is about 80,000,000 of feet (b. m.) per annum; besides large quantities of lath and shingles. A large export of railroad ties, cedar posts, and telegraph poles is also made. About one-fifth part of the lumber is dried and carried by rail; the remaining four-fifths is shipped by vessels.

A large product of this material has been exported formerly, and as an argument in favor of the improvement, an estimate of the extra cost of production, incurred by loading at such a distance from the point of production, is cited. Assuming such extra cost to be 50 cents per 1,000 feet (b. m.), 80,000,000, deducting one-fifth, equals 64,000,000, which, at 50 cents, gives an extra cost of $32,000 per annum.

I took occasion to visit several of the stores for the purpose of ascertaining the character of the goods sold. I particularly noticed at one of the hardware stores that the stock was chiefly of agricultural implements, and the proprietor told me that his trade was formerly almost exclusively in milling gear; now he says his trade with the farmers is larger than with the mills. He stated that he had sold 24 plows this summer.

Oconto County contains a large quantity of fine agricultural land and is being rapidly filled up with settlers. More cereals are grown than are necessary for home consumption, and it is expected that in a few years large exports of grain will be made.

The width of Green Bay in front of the Oconto River is 11 miles, at a right angle to the general trend of the shore of the bay, but a sea from the E. N. E. has a run of 24 miles. This course, which is the longest reach to which it is exposed, is tangent to the outer edge of the shoal off Peshtigo Point, distant 13 miles. This shoal juts out to a distance of 3 miles in a southeasterly direction from the point of land, and gives partial protection to the anchorage where vessels are at present loaded with lumber from the Oconto River. In view of this partial protection and the nearness of the opposite shore of Green Bay, such substantial piers as are required to withstand the force of heavy seas from the open lake, are not required for the improvement in contemplation. An estimate is, therefore, submitted for crib piers of 16 feet in width, to be sunk in a dredged channel. By the map of the survey made in 1870, the distance from the mouth of the river to the line of 12 feet of water in the bay is 2,860 feet. To cover the river mouth in such manner as to prevent the washing of the shore accretions into the channel would require the north pier to be built 100 feet longer, and inside the river the banks would need protection for a further distance of 1,000 feet.

A protection of slabs could be given to both sides of the river at its mouth for this distance.

An estimate of the cost of making this improvement is as follows:

ESTIMATED COST OF CRIB WORK 50′ BY 16′ BY 16′.

36,408 feet b. m. of 12″ by 12″ timber framed, bolted, and sunk in place, at $17 per M	$618 93
5,050 pounds of iron drift bolts, at 4 cents	202 00
73 cords stone ballast, at $5.50	401 50
Total cost of crib 50′ by 16′ by 16′	1,222 43

COST OF FILLING INTERVAL BETWEEN CRIBS AND FOOT-WALK 3 FEET WIDE ON TOP OF PIER.

For 6 cords of brush, at $3 per cord	$18 00
For 4 cords of stone, $5.50	22 00
For 450 feet (b. m.) 3-inch plank for foot-walk, at $12	5 40
For 9 pounds of spikes, at 5 cents	45
For stone foundation:	
For 10 cords of stone, at $5.50	55 00
Total cost of interval, &c	100 85
Total cost of crib	1,222 43
Total cost of 50 feet of pier	1,323 28
	2
Cost of 100 feet of pier, at $26.46½ per foot	2,646 56

FOR DREDGING A CHANNEL FROM THE LINE OF 13 FEET OF WATER IN GREEN BAY, ACROSS BAR TO MOUTH OF OCONTO RIVER, 250 FEET WIDE BY 13 FEET DEEP.

For excavating 225,648 cubic yards of material in place, or adding one-third for scow measurement, 300,864 cubic yards, at 20 cents	$60,172 80
Length of 2 crib piers, 5,800 running feet, at $26.46	153,468 00
For dredging inside mouth of river, 1,250 feet by 200 feet wide, to a depth of 13 feet, 119,864 cubic yards of material (scow measurement), at 16 cents	19,178 24
	232,819 04

ESTIMATED COST OF SLAB PIER REVETMENT FOR 100′ BY 25′ BY 16′.

The piles being 4 feet apart from center to center.

50 piles, each 30 feet long, driven in place on each side of slabs forming pier, at $3.50	$175 00
312 cords of slabs placed in pier, at $2	624 00
200 linear feet of 12″ by 12″ wale timber, at 20 cents	40 00
162½ linear feet of cross-ties, 16 feet apart, at 20 cents	32 50
50 screw bolts, each 26″ long, at 10 pounds each = 500 pounds iron, at 5 cents	25 00
	896 50

This estimate is somewhat conjectural, as it is not precisely known what the cost of handling the slabs would be; it would be safe to infer that a slab pier of the above character could be built for $10 per running foot of pier. The river banks for a distance of 1,000 feet on each side should be thus revetted in connection with the western extremities of the crib piers proposed for the protection of the channel dredged out into the bay. The cost of 2,000 running feet of slab pier, at $10, $20,000.

The excavation required to provide a channel 150 feet wide and 12 feet deep, from the lower bridge in the city of Oconto to the west end of the first reach inside the mouth of river, cutting off the "big bend," equal to 9,800 feet in length, would be 472,392 cubic yards in place, or 629,856 cubic yards, scow measurement, at 15 cents, $94,478.40.

RECAPITULATION.

For excavating channel in Green Bay	$60,172 80
For 2 crib piers, equal to 5,800 feet in length	153,468 00
For dredging inside mouth of river	19,178 24
For 2,000 running feet of slab revetment	20,000 00
For dredging to 12 feet from Oconto to west end first reach	94,478 40
	347,297 44
Adding 10 per cent. for contingent expenses	34,729 74
	382,027 18

It is possible that the construction of one pier on the north side of the dredged channel from the line of 13 feet of water in the bay to the entrance of the river would be sufficient to maintain an open channel, and also that a uniform depth of 10 feet of water in the river would be sufficient for the requirements of commerce. If upon practical test the former conjecture should prove correct, and the latter proposition be accepted, the cost of the undertaking would be materially reduced. Under such assumption an estimate would be as follows:

For 2,950 running feet of crib pier, 16 feet wide, at $26.46	$78,057 00
For 2,000 feet of slab pier inside mouth of river, at $10	20,000 00
For 300,864 cubic yards excavation in Green Bay, at 20 cents	60,172 80
For 119,864 cubic yards excavation inside mouth of river, at 16 cents	19,178 24
For excavation required to provide a channel from lower bridge at Oconto to west end of first reach, inside river, 9,800 feet long, 150 feet wide, and 10 feet deep, 484,672 cubic yards, scow measurement, at 15 cents	72,700 80
	250,108 84
Adding 10 per cent. for contingent expenses	25,010 88
	275,119 72

A still further reduction in the cost could be made, provided it was considered expedient to substitute a slab pier for crib work, for the protection of the outside channel. (Such doubtful protection is, however, not recommended.)

The extra cost of labor in laying the slabs and making them secure would not probably exceed $1 per cord of 128 cubic feet, or $312 per 100 running feet of pier, and the

extra cost of driving 50 piles in the bay, at 50 cents each, $25, together making the sum of $337, which added to $1,000 (the estimated cost of slab pier inside the river) makes a cost per running foot of $13.37.

Then 2,950 feet of crib pier would cost as per above estimate	$78,057 00
And 2,950 feet of slab pier, at $13.37	39,441 50
Reducing the last estimate to the extent of	38,615 50

In the above estimates no provision has been made for the revetment of the river banks above the first inner reach of 1,000 feet. Experience alone can prove whether such protection would be necessary.

The extent of the action which the current would produce upon the river banks cannot be known before such changes as have been contemplated in this report are made.

The prices stated for materials and labor in the above estimates are based upon the supposition of liberal appropriations being made for the work.

I herewith inclose a tracing of map drawn by Mr. R. L. Hall, county surveyor, upon which I have plotted a portion of the soundings taken by me as accurately as practicable.

With great respect, I beg to subscribe myself your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Bvt. Col. D. C. HOUSTON,
Major of Engineers, U. S. A.

D D 7.

SURVEY OF WOLF RIVER, WISCONSIN.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., November 25, 1879.

GENERAL: I have the honor to transmit herewith a report by Mr. John Pierpont, assistant engineer, on the survey of Wolf River, Wisconsin (continued), called for by the harbor and river act approved March 3, 1879.

An examination of this river from Lake Poygan to Red River was made in 1878, under the act approved June 18, 1878, and a report published in Senate Executive Document No. 28, 3d session 45th Congress. The estimates for improvement did not extend above Semple's Bridge, which was practically the head of navigation. The object of continuing the survey is indicated in a communication from Hon. T. C. Pound to the honorable Secretary of War, dated March 19, 1879, in which he says, "It is desired that the work be continued to the city of Shawano." The estimated cost of improving the river from Semple's Bridge to Shawano, by dredging a channel 80 feet wide and 3½ feet deep at low-water, is $43,500. This, added to the estimate of last season for improvement below Semple's Bridge, makes a total estimate of $78,500.

General Orders No. 2, headquarters Corps of Engineers, dated March 15, 1879, called for "full statements of all existing facts tending to show to what extent the general commerce of the country will be promoted by the several works of improvement contemplated by such examinations and surveys, to the end that public moneys shall not be applied, excepting where such improvements shall tend to subserve the general commercial and navigation interests of the United States." All the obtainable information bearing on this subject is given in the report of last season's examination above referred to, and the letter of Mr. J. D. Kast, of Shawano, which accompanies this report.

There is no existing navigation above Semple's Bridge, which has no opening for the passage of boats. To establish navigation up to the

Shawano would require the construction of three draw-bridges. There does not appear to be any great demand for the improvement of this river. The business (present and prospective) does not warrant any large expenditure.

As stated in my last season's report, existing navigation would be benefited by removal of snags, leaning trees, &c.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JOHN PIERPONT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., November 22, 1879.

SIR: Acting under your instructions to proceed to Shawano, Wis., and make such examination of the Wolf River as would enable me to submit a plan and estimate of cost for extending the improvement of the river upon the plan contemplated in my examination and report of last season, I have the honor to state that I have made the survey needed, and respectfully report as follows:

The river and harbor act of June 18, 1878, provided for the examination of the Wolf River from Lake Poygan to the Red River, Wisconsin.

Acting under your direction, I made the reconnaissance during August, 1878, and my report dated November 26, 1878, was published as Senate Executive Document No. 23, third session Forty-fifth Congress. In this report I stated that a point about ten miles below Red River, and called Shawano Rocky, was the head of natural navigation, but that Semple's Bridge, about four miles below, was the real head, as the bridge had no draw, and I was compelled to abandon the light-draught, stern-wheel steam-scow in which the examination had been made, and proceeded the remainder of the distance in a skiff. Considering this bridge as the head of navigation, my estimates for the improvement of the river were carried to this point only. The second section of the river and harbor act of March 3, 1879, provided for a continuation of the examination of the Wolf River, and, instructed by you, I wrote, under date of May 22, 1879, to the Hon. J. D. Kast, of Shawano, asking how far it was desired to extend the examination. In his reply, dated June 3, 1879, he stated that the river should be improved up to the town line bridge near the city of Shawano. As this letter from Mr. Kast contains all the information bearing upon the necessity of improving the river up to Shawano, the resources and population of the country that would be benefited, I append the letter to this report.

I arrived in Shawano on the 25th day of August, 1879, organized a party, and commenced the survey at the point indicated by Mr. Kast as that to which the improvement should be carried, about 500 feet below the outlet of Shawano Lake.

A water-gauge was set up at this point and also one at Semple's Bridge, and daily observations taken during the time the survey was being carried on.

The gauges were set up nearly at the same time, the zero of each gauge being placed at the water surface as it existed at the time they were put in position. Starting from the upper water-gauge, a transit line was run down the river to Semple's Bridge, and stations established along the line at intervals of 200 feet, numbered consecutively from 1 to 243. The line was run sometimes on one side of the river and sometimes upon the other side, that side being chosen which presented the fewest natural obstacles. Having stretched a chalk-line by soaking it thoroughly and winding it as tightly as possible while still wet around a tree and allowing it to dry in this condition, it was divided into intervals of 20 feet by cloth tags, every fifth tag of 100 feet mark being white, while all the others were red. Holding one end of the line at each station on the transit line, it was stretched across the river, its magnetic bearing noted with the prismatic compass held at the station; the distance from the station to each bank of the river measured on the line, and the depth of water sounded at each of the tags. While this work was being carried on, a bench-mark was established on an oak tree near the upper gauge, and one on one of the crib piers of Semple's Bridge, near the lower gauge, and a line of levels run from the upper to the lower bench-mark and back again, by Mr. J. P. Vose. The sum of the fore-sights running down the river was 5.673 feet greater than the sum of the back-sights. The sum of the back-sights in running back was 5.846 feet greater than the fore-sights, showing a dif-

ference of .173 foot. The upper bench-mark is 3.225 feet above the zero of the upper gauge, and the lower bench-mark is 5.283 feet above the zero of the lower gauge, giving a difference between the zeros of the gauges or total fall of water-surface of 7.904 feet. The distance between the gauges is 9 miles, giving a slope of water-surface of·0.878 foot per mile. While running the line down the river, the elevation of the water-surface was noted at intervals of about ¼ mile; but as the stage of water varied so from day to day, and the gauges were too far apart to make a reduction to any plane reliable, and as the levels showed the slope of the surface to be so small, I have not prepared a profile. A map of the survey has been made on a scale of 1 inch to 200 feet, and is on 2 sheets, the river crossing each sheet twice. The map shows the river with the adjacent topography. The hills are indicated approximately by red contours, and the estimated heights noted. The soundings taken in the river are expressed in feet and tenths, and are reduced to a plane 5 inches below the zeros of the water-gauges, which was the lowest stage recorded during the survey. The soundings were all taken in three days, and as the third day was the one in which the lowest water occurred, the reductions necessary were very slight, not to exceed .2 of a foot.

The estimates made during the preceding year were for 3.5 feet depth at low-water. In order to carry the estimates upon this basis to the upper end of the survey, I attempted to draw the 3.5-foot curves in the river, but finding very few places upon the upper half of the river surveyed where that depth of water obtained, I abandoned the idea, and sketched in the 2-foot and 3-foot curves instead, which are shown respectively by a black and by a blue line.

The river below Semple's Bridge, as explained in my previous report, is generally narrow and exceedingly tortuous; the shoals occur only in the wider portion of the river, and as they are composed entirely of sand, I considered that the required depth of water could be readily obtained by narrowing the river by a system of brush and stone wing-dams, removing snags and leaning trees. Above Semple's Bridge, however, the character of the river changes, the horseshoe bend being replaced by long curves connected by reaches of straight river. The river becomes wide and shoal, the bed being composed of sand, gravel, soft mud, and bowlders. There is no rock in place, and none of the bowlders are so large as to require blasting for their removal. The only method of improvement that seems practicable is to dredge a channel 3.5 feet deep and of such width as to accommodate any of the boats that may ply upon the river. This width I have taken to be 80 feet, and have indicated the proposed channel by two red lines on the map, and estimate the amount of dredging as follows.

As I stated before, the river is platted upon the maps in 4 lengths, and for the convenience of computation, as well as to show how the water shoals as the river is ascended, I will consider each section by itself, and give the results in the following table:

	Length.	Width.	Area.	Mean depth.	Depth of cut.	Excavation.
	Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Cub. yds.*
Lower section	7, 500	80	600, 000	3. 03	0. 47	10, 074
Second section	14, 600	80	1, 168, 000	3. 06	0. 44	19, 034
Third section	11, 500	80	920, 000	2. 44	1. 06	36, 107
Upper section	14, 000	80	1, 120, 000	2. 74	0. 76	31, 526
Total	47, 600					96, 741

In computing the mean depth, all soundings over 3.5 feet were taken at 3.5 feet. I estimate the cost of this excavation at 40 cents per cubic yard. The material excavated should be combined with brush and made into wing-dams, jetties, and other structures, confining the water while at low stage to the channel dredged out, thus making it permanent. The cost of this, as well as the increased expense due to the shallowness of the cut, I think will all be covered by the price given.

On the 30th of August, 1879, I measured the volume of discharge of the river above Semple's Bridge. Two cross-sections, 100 feet from each other and perpendicular to the current, were measured, the soundings being taken at intervals of 20 feet.

The velocity of the current I measured by an ordinary wooden water-pail sunk by a few stones to the mid depth and suspended by a piece of twine to a small cedar block, which, floating on the surface, served to indicate the position of the pail.

The float was run three times in the center of the stream and half way between the center and each bank. The average time required for the float to pass over the distance of 100 feet was 77 seconds, giving a velocity of 1.3 feet per second. The mean depth of the two cross-sections was 3¼ feet. The mean area was 525 square feet, giving a discharge of 682 cubic feet per second. The water at this time was 2 inches below the zeros of the two gauges.

The area reduced to the low-water plane of the survey would be 487.5 square feet, and the discharge 633.7 cubic feet per second, assuming the velocity to remain unchanged. On August 14, 1878, I measured the volume at Semple's Bridge, making one cross-section and noting the time required for a chip to float down a distance of 20 feet from a point 10 feet above the measured cross-section to 10 feet below. I assumed the mean velocity of the river to be 85 per cent. of that of the surface, and obtained a discharge of 809.2 cubic feet per second, or 175.5 cubic feet more than the discharge of this year, showing that the river was lower this year than last. In order to ascertain, if possible, how much lower the river was when taken at the stage to which the soundings are reduced (5 inches below the zeros of the two gauges), I have computed the mean depth of water along the channel-line between the outlet of Shawano Lake and Semple's Bridge, and find it to be 2.82 feet, which is the mean of 235 soundings. While descending the river in a skiff on the 15th day of August, 1878, I took a line of soundings in the channel, and found the mean depth of water between the same limits as before to be 2.81 feet, deduced from 205 soundings, showing that the low-water during my examination this year was practically the same as that of last, and that the measurements of the volume of discharge are not reliable. It is unfortunate that there are no positively reliable means of comparing the stages of water for the two years, but I think any great difference would be shown by the averages of the lines of soundings, each 9 miles long and taken nearly in the middle of the river.

On the 4th day of September last, having completed the survey, I went to Semple's Bridge to get the records of the water-gauge at that point, and found that the water was 15 inches below the zero of the guage, viz, 10 inches below what I considered the low-water of the river. Inquiring as to the cause of this sudden and remarkable fall, I was told that the company owning the flood-dams on the Upper Wolf were engaged in blasting the rock and improving the channel below one of their dams, and were holding back the water in order to do the work with greater ease and economy. There are 6 of these dams already built on the main Wolf and 2 more proposed. There are 5 dams on the Lily River, 1 on the Hunting, 1 on the Pickerel, and 7 on the Red River—a total of 22 when all are done; enough, if they were all closed, to make the Wolf River dwindle to an insignificant stream and render its improvement practically impossible. I believe, however, that the stage of water I found during the examination of both years to be very near the natural low-water stage of the river, and that the improvement of the river to obtain 3.5 feet of water at this stage up to Shawano can be permanently made by excavating the channel shown on the maps, the cost of which will be as follows:

Excavating 96,741 cubic yards, at 40 cents per yard	$38,696 40
Engineering and contingencies, about 11 per cent	4,303 60
Total	43,000 00

As the expense of putting draws into the three bridges which cross the river within the limits of the survey should fall upon the county of Shawano, I have omitted it in the estimate of cost.

Very respectfully, your obedient servant,

JOHN PIERPONT,
Assistant Engineer.

Bvt. Col. D. C. HOUSTON,
Major of Engineers, U. S. A.

COMMERCIAL STATISTICS.

SHAWANO, *June* 3, 1879.

DEAR SIR: In response to yours of the 22d of May, I would respectfully suggest that if an improvement of Wolf River is to be of practical value to the country which it drains, it should extend to the present head of navigation, which is the town-line bridge at the city of Shawano, because Shawano is the county seat of Shawano County, is the center of the lumber and nearly all other business of the county, has the country roads leading to it, and is just below the confluence of the Shawano River, connecting Lake Shawano with the Wolf and the Red River, which enters the Wolf about 3 miles above the town-line bridge, the present head of navigation.

It is the first point on Wolf River that can be reached by shipping, which has an abundance of water power (yet partly undeveloped), and a still greater abundance of material for manufacturing, in easy reach, partly by the navigable Lake Shawano and its outlet. And the cost of improving the river from Semple's Bridge up to Shawano would be a mere trifle compared with the advantage it would afford the country.

The first important article to be manufactured by water-power is wheat, for the growth of which there is an immense territory east, north, and west of Shawano.

The surplus of this cereal subject to the Shawano market was about 100,000 bushels, and is increasing at from 25 to 50 per cent. per annum, all of which must now be carted on country roads to Green Bay or Clintonville, the nearest railroad stations.

The next most important article to be manufactured and shipped at Shawano is the hard-wood timber, of which half a billion of feet would be in reach of this point were transportation easy or even possible. An immense amount of poplar wood for paper pulp and hemlock bark for tanning is close at hand. The sandy soils of the Wolf and Oconto River Valleys would produce large quantities of potatoes of the most superior quality could the article be shipped, also of buckwheat and hops. The dairy productions would be almost unlimited if transportation was made easy. Sand and limestone quarries close to the banks of Wolf River might also demand shipping if the river would permit it. The pine timber in the immediate vicinity is nearly exhausted, but there are over two billion of feet on the Upper Wolf and tributaries, of which large quantities would be manufactured when cheap water power and easy transportation could first be reached. The future will also bring an almost unlimited amount of hemlock timber into use and commerce. The present population and business of two tiers of towns on each side of Wolf River is about as follows:

Langlade, estimated population 600, has 10 hotels, 3 stores, 1 saw-mill.

Keshena (Indian reserve), population 1,500, 1 store, 2 hotels, 1 grist-mill, 1 saw-mill.

Stockbridge (Indian reserve), population 150.

Herman, population 550.

Richmond, estimated population 600, has 1 saw-mill.

City of Shawano, population 1,000, 9 stores, 5 hotels, 1 grist-mill, 1 saw-mill, 1 factory, large number of shops.

Bellplain, population 950, 2 stores, 1 hotel, 1 saw-mill, 1 factory.

Waukecheon, population 850, 1 store, 1 saw-mill, 1 hotel.

Washington, 1 store, 1 saw-mill, population 900.

Hartland, population 1,000, 2 stores, 2 grist-mills, 2 saw-mills, 2 hotels, and number of shops.

Navarino, 1 hotel, population 350.

Pella, population 850, 1 grist-mill, 1 store, 1 hotel.

Lesser, population 500.

Matteson (Waupaca County), 1 grist-mill, 2 stores, 2 hotels, 1 saw-mill.

Ten years ago the number of inhabitants in this district was less than 3,000.

The trade in merchandise and lumber supplies is over 2,000 tons annually, and if the Wolf River is improved there will be abundance more.

I am, very respectfully,

J. D. KAST.

JOHN PIERPONT, Esq.,
Assistant Engineer.

APPENDIX E E.

IMPROVEMENT OF HARBORS OF CHICAGO AND CALUMET, LAKE MICHIGAN—IMPROVEMENT OF ILLINOIS RIVER.

REPORT OF MAJOR G. J. LYDECKER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 15, 1880.

GENERAL: I have the honor to transmit herewith annual reports of operations for works in my charge for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

E E 1.

IMPROVEMENT OF THE HARBOR AT CHICAGO, ILLINOIS.

The work in hand during the fiscal year has been the construction of the southerly breakwater designed to close the outer harbor against the violence of southeasterly storms. At the commencement of the year 8 cribs were in position, these constituting the substructure for 800 linear feet of breakwater, of which 100 feet was 30 feet wide, and the remaining 700 feet 16 feet wide. Besides this there were 3 cribs framed and ready for sinking.

PROGRESS DURING THE FISCAL YEAR.

Operations were in progress from July 1 to December 1, 1879, when preparations were made to suspend during the winter. In the meantime arrangements were made by which the timber required for the completion of the work would be cut, hauled, and sawed during the winter, so as to have it in readiness for delivery on the opening of lake navigation in the spring. Operations were resumed about the middle of April, 1880, and have been continued up to the present time, with many interruptions on account of unfavorable weather, and delays arising from the non-delivery of piles.

The results of the year's work are as follows: 974 piles for crib foundations have been driven and sawed off at a level of 4½ feet below the water surface; 17 cribs, each 100 by 16 by 14½ feet, and 2 cribs, each 100 by 30 by 14½ feet have been built and sunk in position on their pile foundations. The superstructure, to its full height of six courses, has been placed on 2,300 linear feet of breakwater, being over all the cribs that were in position at the time operations were suspended for the winter.

The last 4 cribs on which the superstructure was placed have settled through a distance of about 4 foot, owing to an underlying stratum of soft mud; it will have to be rebuilt. A decking of plank has been placed over half the width of the 30-foot cribs, and over all the wells between the cribs, and a plank walk has been laid along the middle of the 16-foot cribs, whose superstructure is completed.

CONDITION OF THE WORK JUNE 30, 1880.

The total length of the breakwater when finished will be 3,000 feet. Of this, we have 300 linear feet 30 feet wide, and 1,600 linear feet, 16 feet wide, with superstructure, completed; 800 linear feet 16 feet wide, in position, requiring 4 courses of superstructure for its completion; the three cribs (300 linear feet) required for completing the breakwater are built, and will be sunk as soon as the pile foundation, now about half finished, is in readiness.

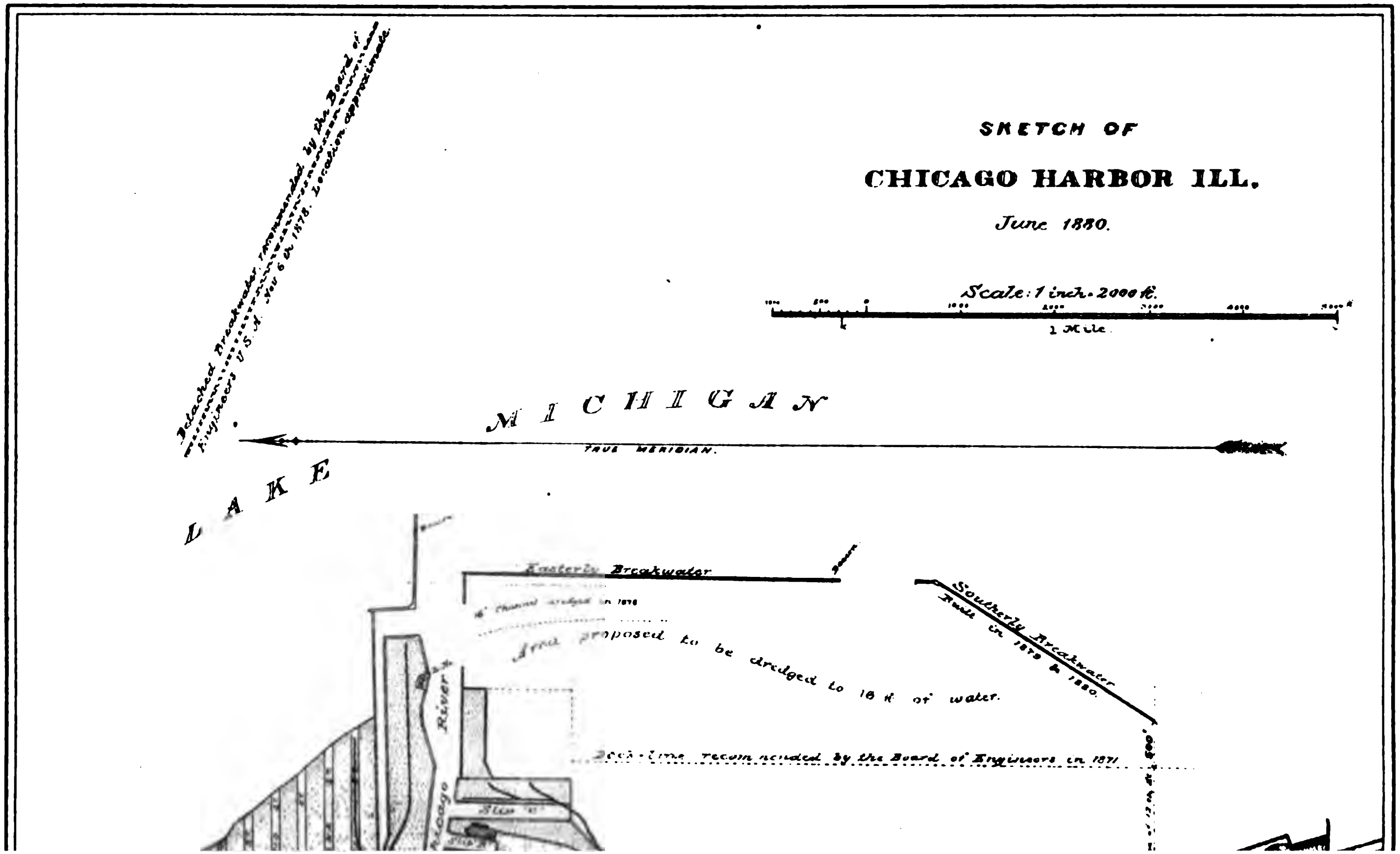
The entire work is in good condition, except the 4 settled cribs, which can be built up again and leveled in the usual manner with but little trouble or expense. The cribs are in excellent line, and on their bearing-pile foundation have maintained their level in a most satisfactory manner. With favorable weather and the prompt delivery of material that has been ordered the entire work will be completed by the end of the present month.

The depth of water in which this breakwater is built varies from 15 to 20 feet; the estimated cost was $135,500, but its actual cost, including all contingencies, will not exceed $125,000, or about $42 per linear foot. The time occupied in its construction will be but little over one year, the first crib having been sunk June 8, 1879. The location and details of construction are shown on the plates published in the report of the Chief of Engineers for 1879, p. 1560. All work has been done by hired labor, and all material purchased in open market, except 463,632 feet (board measure) pine timber, 1,653,468 feet (board measure) hemlock timber, and 20,580 linear feet piles, this material having been furnished by George Hannahs under his contract dated February 10, 1879.

PROPOSED APPLICATION OF FUNDS AVAILABLE.

The total amount available for the fiscal year ending June 30, 1881, is $170,121.77, of which $145,000 was appropriated by the act approved June 14, 1880, and $25,121.77 is the balance of the previous appropriation. The latter sum will be applied to completing the southerly breakwater, in pursuance of the project for its expenditure approved August 1, 1879.

When the breakwater is finished the present plan of improvement contemplates the dredging of the outer harbor to a uniform depth of 16 feet, the westerly limit of this dredging being the dock line established by the Board of Engineers convened by Special Orders No. 168, Headquarters Corps of Engineers, August 3, 1871.


SKETCH OF
CHICAGO HARBOR ILL.
June 1880.
Scale: 1 inch = 2000 ft.
1 Mile.
Detached Breakwater recommended by the Board of Engineers U.S.A. Nov 6 th 1878. Location approximate.
LAKE
MICHIGAN
TRUE MERIDIAN.
Easterly Breakwater
Area proposed to be dredged to 16 ft of water.
Southerly Breakwater Built in 1879 & 1880.
Dock-Line recommended by the Board of Engineers in 1871
River
Slip

A portion of this work was done in 1878. The approximate amount of excavation required for its completion is 575,000 cubic yards. When finished the total area sheltered by the breakwaters, and affording a depth of water of not less than 16 feet, will be 270 acres. It is proposed to apply $45,000 of the present appropriation to this purpose. With this amount it is believed that about 225,000 cubic yards can be excavated, the amount depending, of course, on the price at which we may be able to have the work done by contract.

In addition to completing the outer harbor, the plan of improvement recommended by the Board of Engineers convened by Special Orders No. 80, Headquarters Corps of Engineers, July 24, 1878, provides for the "construction of a breakwater to the north and east of the present north pier, between which vessels seeking this port can anchor in security, and be able to select a favorable opportunity to enter the river."

The reasons for this recommendation were set forth in a letter which I addressed to the president of the Board, and which is printed in the report of the Chief of Engineers for 1879, pp. 1562–1567. The Board's recommendation was concurred in by the Chief of Engineers, and approved by the honorable Secretary of War; the act approved June 14, 1880, provides especially for the commencement of this exterior breakwater, and it is proposed to apply the sum of $100,000 to this purpose. At this writing, the exact location and plan of construction have not been decided upon; for this reason, it will probably be impossible to commence operations before the middle of August; accumulation of heavy timber required for such a work will be a difficult, slow, and expensive affair at this season of the year, and it will not be practicable to get any considerable length of the breakwater in place before the close of the present working season; a short piece of detached work in the track of vessels seeking this port would serve no useful purpose, but, on the contrary, be an obstruction to navigation. Therefore, I recommended in my project of June 24, 1880, that no work should be put in place this season, but that we build a few cribs before winter, to have them in readiness for sinking early next spring, and that a large bill of timber be taken out during the winter. In this way, with a large appropriation next year, we will be able to push the work rapidly and economically. I found this course most advantageous in constructing the southerly breakwater, and am satisfied that we can do no better than to repeat it in the work before us.

The construction of a breakwater located as this one is, in depths varying from 25 to 35 feet, and directly exposed to the severe northeasters which visit this locality, is an undertaking of considerable magnitude, and it cannot be accomplished with success and economy unless adequate means are supplied; the object to be subserved is an important one, and the vast lake commerce seeking this port, as well as vessels driven to this corner of the lake by stress of weather, is deeply interested in obtaining at the earliest date the additional security which will be afforded by the projected work; finally, as before stated, this breakwater will not only be useless, but absolutely detrimental to the interests it is designed to promote, from the time it is commenced until a considerable portion has been completed. For the foregoing reasons I would urge that the appropriation for the fiscal year ending June 30, 1882, be at least $300,000, to be applied as follows: for continuing construction of breakwater, $250,000, and for dredging the outer harbor, $50,000. It is to be observed that the advantages contemplated by the work already done cannot be realized until the basin sheltered by the breakwaters is dredged to the necessary depth.

Pending decision as to the exact location and plan of construction of the exterior breakwater, a precise estimate of cost of the present plan of improvement is impracticable. The approximate estimate, based on the suggested location and plan, was $855,500; at the time of its adoption there was available the sum of $55,500; since then appropriations have been made as follows: by the act approved March 3, 1879, the sum of $75,000; by the act approved June 14, 1880, the sum of $145,000; thus making the total applicable to date $275,500. Of this amount there had been expended to June 30, 1880, the sum of $105,378.23. The approximate amount, exclusive of former appropriations, required for the completion of the present project, is $580,000. After this is done it is probable that an extension of the detached breakwater to the shore, its connection with the end of present north pier, the extension of the latter, or dredging near its end, will be necessary to prevent the entrance to the harbor being blocked by accretions which form to the north of the piers. The best solution of this problem must be a subject of future study.

Chicago is a port of entry, is in the collection district of Chicago; there is a light-house on the shore end, and a beacon-light on the lake end of the north pier; there is also a beacon-light on the south end of the easterly breakwater.

Number of vessels entered during the year	12,115
Number of vessels cleared during the year	12,208
Total tonnage of vessels entered and cleared	8,453,302
Amount of revenue collected	$2,273,757 57

Not only the commerce of Chicago, but all vessels approaching the south end of Lake Michigan are interested in the completion of the projected works, especially that designed for establishing a safe harbor of refuge.

Money statement.

July 1, 1879, amount available	$107,464 00	
Amount appropriated by act approved June 14, 1880	145,000 00	
		$252,464 00
July 1, 1880, amount expended during fiscal year	82,342 23	
July 1, 1880, outstanding liabilities	3,829 81	
		86,172 04
July 1 1880, amount available		166,291 96
Amount (estimated) required for completion of existing project		580,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		300,000 00

Abstract of contract in force in the fiscal year ending June 30, 1880.

With—	Dated—	Expires—	Extended to—
George Hannahs	Feb. 10, 1879	June 30, 1879	Aug. 1, 1879

E E 2.

IMPROVEMENT OF THE HARBOR OF CALUMET, ILLINOIS.

The project in course of execution at this place includes the construction of piers extending to deep water for preserving the channel by which an entrance to the river is secured and maintained. The amount available July 1, 1879, was $14,805.67, of which $12,000 was the sum appropriated by the act approved March 3, 1879.

PROGRESS DURING THE FISCAL YEAR.

In pursuance of the project approved May 22, 1879, and upon receipt of instructions dated July 30, 1879, notifying me that the money appropriated had been made available, advertisements for proposals for extending the north pier 300 feet were published August 9, 1879. Bids were opened August 28, and the contract awarded to Culbert Brothers, they being the lowest bidders. The contract was executed September 16 for constructing 200 linear feet of pier work, the reduction from the length contemplated in the advertisement being on account of the prices at which the contract was let.

Operations were commenced at once, and the contractor was engaged during the balance of that month procuring the necessary material for the work—a slow process, so far as timber is concerned, at that season of the year. During October the pile foundations were completed, and 2 cribs—each 100 by 20 by 14½ feet—were built. During November these were sunk, the superstructure was completed, and the contract with Culbert Brothers closed. The amount paid them was $11,463.17, making the cost $57.33 per linear foot, exclusive of engineering contingencies and superintendence.

In addition to this work, a dredge was employed 10½ days in excavating a channel through the bar at the entrance to the harbor; some slight repairs were made to the old piers, and about 60 cords of stone were transferred from parts of the shore ends of the piers, where it was no longer needed, to the more exposed parts of the work where additional filling was required. This work, and the repairs alluded to, were done by hired labor. All work was suspended in December, 1879, since which time no work of construction has been in progress.

In June, 1880, a local survey was made to ascertain what recent changes had taken place and to aid in determining the project of operations for the present fiscal year.

CONDITION OF THE WORK JUNE 30, 1880.

This is shown on the sketch transmitted herewith. The north pier, the total length of which is 2,940 feet, is not yet sufficiently long to prevent the bar formation at the harbor entrance; the end of the pier reaches to the line of the 15-foot curve, though the depth of water just off the end is considerably greater; but this increased depth is due to the current which sets around the pier and carries sand into the channel; a general advance of the shore line and accretions north of the pier is indicated, and it is probable that this will continue—with a diminished rate, however—for some period of time to come. Excepting in times of storm, vessels drawing 12½ feet may now enter in safety, at ordinary low-water, and pass up the channel between the piers.

PROPOSED APPLICATION OF FUNDS AVAILABLE.

The amount available June 30, 1880, was $20,708.16, of which $20,000 was appropriated by the act approved June 14, 1880.

The project for its expenditure, as submitted in my letter to the Chief of Engineers dated June 24, is to apply $15,000 to extending the north pier, and $5,000 to dredging. With these amounts it is believed that 250 feet may be added to the length of the pier, and that the bar at the entrance of the harbor may be dredged to a depth of 15 feet below low-water for the full width of the channel.

The industries now centering at South Chicago, raise the importance of this harbor for commercial purposes to a point never before reached.

The class of vessels engaged in the iron trade which is rapidly growing up in that vicinity calls for a low-water depth between the piers of not less than 15 feet. The estimated amount of dredging for this purpose, in addition to what may be done this year, is 85,000 cubic yards. I do not believe that the bar formation at the entrance of the harbor can be prevented until the end of the north pier is carried out to, and maintained in, 20 feet of water; as indicated by the recent survey, this will require an extension of 500 feet, in addition to what can be done with the present appropriation.

The estimated cost of the work above indicated, if done with small annual appropriations, such as the late ones have been, is as follows:

For dredging 85,000 cubic yards, at 25 cents	$21,250
For pier extension, 500 linear feet, at $75	37,500
Total	58,750

If an appropriation sufficient to do the work in one fiscal year could be obtained, the total cost would be reduced at least 15 per cent., in round numbers to $50,000.

This amount could be profitably expended the next year, and I therefore recommend its appropriation for the fiscal year ending June 30, 1882. By so doing there will be a saving in cost, and the immediate wants of commerce will be satisfied.

The original project for improving this harbor was presented by Maj. J. B. Wheeler, Corps of Engineers, and contemplated dredging in the river, near the lower bend which then existed, a straight cut from the bend through the sand point near the light-house, the construction of two parallel piers 300 feet apart extending out to the 12-foot curve, and dredging between the piers. His estimate, as shown on page 107, Report Chief of Engineers for 1870, was as follows:

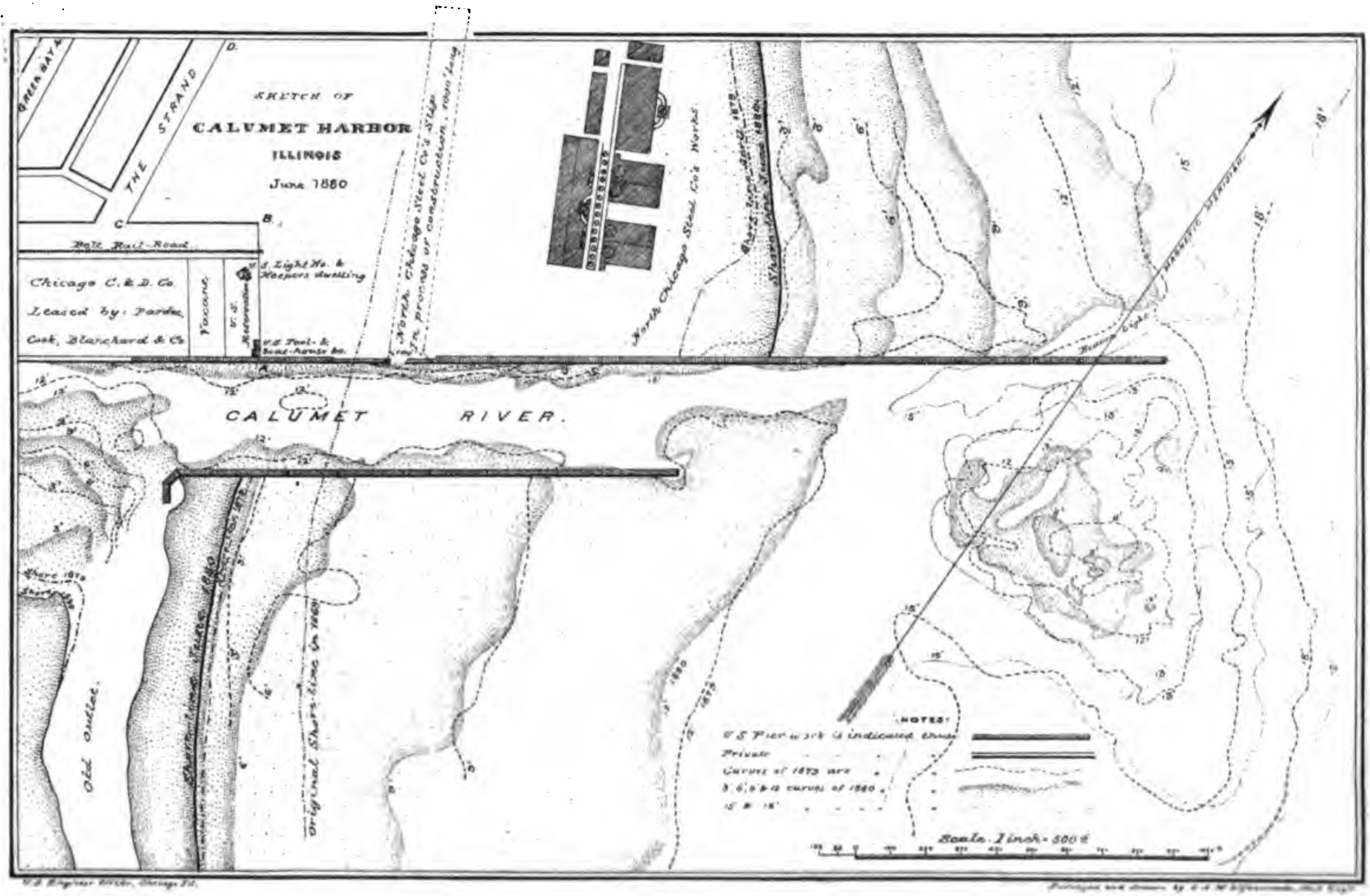
For 4,096 linear feet piers	$221,771 52
For dredging (3,304.16 cubic yards)	78,104 00
Total	299,875 52

This estimate for dredging supposed the channel to be made 13½ feet deep, and that the work be done by machinery owned and operated by the United States; Major Wheeler stating in his report, "if done by contract the item for dredging should be doubled."

Up to June 30, 1880, there had been appropriated $297,000, of which there has been expended $276,291.84. The total length of piers built to date is 4,460 linear feet, and the total amount of dredging done is 234,000 cubic yards. The amount, exclusive of former appropriations, required for the completion of the present project, as per estimate given above, is $58,750, being $55,874.48 in excess of the original estimate; the latter was for piers extending to 12 feet of water and for dredging to 13½ feet, the former is for carrying the north pier to a depth of 20 feet and dredging to a depth of 15 feet. The necessity for the increased depth arises from the increased draught of vessels now in ordinary use, and the pier extension is required for preserving the channel.

The harbor of Calumet is at South Chicago, in the collection district of Chicago. There is a light-house and keeper's dwelling on the reservation near the shore end of the north pier, but the light is not maintained. A beacon light near the end of the pier is kept up to mark the entrance to the harbor.

Number of vessels entered during the year	79
Number of vessels cleared during the year	79
Total tonnage of vessels entered and cleared	214.16
Amount of revenue collected	$90 70



SKETCH OF
CALUMET HARBOR
ILLINOIS
June 1880
GREEN BAY A.
THE STRAND
Belt Rail-Road
Chicago C. & D. Co.
Leased by: Pardee, Cook, Blanchard & Co.
Vacant
U.S. Reservation
U.S. Light Ho. & Keepers dwelling
U.S. Tool- & boat-house &c.
North Chicago Steel Co's Slip. In process of construction. 1000' long
North Chicago Steel Co's Works.
CALUMET RIVER.
Old Outlet.
Original Shore-line in 1869
NOTES:
U.S. Pier work is indicated thus
Private
Scale. 1 inch = 500 ft.

The principal commerce of the port pertains to the lumber and iron interests. The latter will be largely increased before the close of the current year, when the extensive works now in rapid course of construction by the North Chicago Steel Company shall be completed; the location of these works is shown on the sketch of the harbor accompanying this report. Mr. O. W. Potter, president of the company, in a letter addressed to me July 6, 1880, states:

The iron industries now located at South Chicago are the Duffy Tool Company, the Joseph H. Brown Iron and Steel Works, and the North Chicago Steel Company.

Their annual tonnage in finished product, of pig-metal, steel rails, merchant bars, and nails, would be 200,000 tons per annum, and would call for a lake commerce in iron ore, coal, and limestone of at least 375,000 gross tons per annum. All of this lake commerce must, from its nature, be in the largest class of vessels that navigate the lakes, it being transported generally in the large vessels in the grain carriers' trade between Buffalo and Chicago.

The North Chicago Steel Company has provided for a depth of 15 feet of water in its canal, as the class of vessels, if loaded to the capacity they are capable of carrying, would, as a rule, be loaded to from 14 to 14½ feet of water.

It is claimed that the amount of lumber that will be handled here during the current season will exceed 15,000,000 feet, board measure.

Referring to the sketch of the harbor, it will be observed that entrance to the canal, or slip, which the North Chicago Steel Company is now constructing, is obtained by a cut through the Government Pier; authority to make this cut was given, subject to certain conditions which are fully explained in the letters and deed appended to this report, in connection with which, I would suggest they be printed,* as the surest means of preserving a connected and conspicuous record of facts on which the interests of the United States depend.

Money statement.

July 1, 1879, amount available	$14,805 67	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$34,805 67
July 1, 1880, amount expended during fiscal year		14,097 51
July 1, 1880, amount available		20,708 16
Amount (estimated) required for completion of existing project		58,750 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		50,000 00

Abstract of proposals for furnishing materials and labor, received and opened August 28, 1879.

Number.	Name.	Residence.	25,360 feet (b. m.) pine timber and plank.	88,900 feet (b. m.) hemlock timber.	40 pine piles.	9,310.05 pounds drift-bolts.
			Per M.	*Per M.*	*Each.*	*Per lb.*
1	Cuthbert Brothers	Michigan City, Ind	$24 00	$22 50	$8 75	$0 04
2	Chicago Dredging and Dock Company.	Chicago, Ill	26 00	26 00	14 00	05
3	O. B. Green	do	26 50	26 50	13 80	05

* Omitted.

Number.	Name.	Residence.	640 pounds screw bolts.	150 p'uds spikes.	246.804 cords stone.	Total for 100 linear feet of work.
			Per lb.	*Per lb.*	*Per cord.*	
1	Cuthbert Brothers	Michigan City, Ind	$0 04½	$0 04	$8 00	$5, 340 94
2	Chicago Dredging and Dock Company.	Chicago, Ill	07	04	9 00	6, 268 72
3	O. B. Green	do	06¼	03⅝	9 10	6, 339 90

Contract awarded to Cuthbert Brothers.

Abstract of contracts in force in the fiscal year ending June 30, 1880.

With—	Dated—	Expires—
Cuthbert Brothers	September 16, 1879	November 30, 1879.

E E 3.

IMPROVEMENT OF ILLINOIS RIVER.

At the beginning of the year the outfit for building brush and stone dams and for dredging was awaiting completion and trial at Peoria, where the work of construction had been in progress since the middle of February, 1879. That part of the outfit designed for dredging consisted of 1 "dipper" dredge, 2 dump-scows, and 1 tow-boat; the latter being in process of construction at Saint Louis, by the Western Iron Boat Building Company; the plant for building dams consisted of 1 steam-scow and 2 deck-scows; in addition there were 2 quarter boats for the accommodation of the full working force.

PROGRESS DURING THE FISCAL YEAR.

Work on the dredge and steam-scow was continued until July 15, 1880, when preliminary trials of the machinery were commenced; everything having been placed in fair working order, the entire fleet, in tow of the steam-scow, was started down the river on the 19th; at Lancaster a coal barge containing 3,600 bushels of coal was added to the fleet, and leaving there on the morning of the 20th the trip was continued down to Pearl Shoals, the point at which the season's work was to begin, and which was reached on the evening of the 22d. The working of the steam-scow, and the manner in which she handled her large tow on this trip, was most satisfactory. A trial of the tow-boat at Saint Louis was arranged for the 23d, but on our arrival there she was found incomplete, and left for the builders to finish as per agreement; the trial was finally made August 1, and though not satisfactory in all respects, it was deemed advisable to accept her, in order to expedite the commencement of operations on the river.

In the meantime the working organization had been perfected; the accumulation of material for dams had been commenced, and the channel which it was designed to make had been marked out; dredging was commenced August 6, though some desultory work had been done pre-

vious to that, while adjusting the machinery and strengthening some parts of the crane where indications of weakness were observed; work on the dams was commenced August 7, immediately on completing the pile-driver, which had been built since reaching Pearl Shoals.

Work was continued until the middle of December, when the force was reduced, and winter quarters were stationed near Kampsville, about 1 mile below Silver Creek; the river was closed by ice in this locality December 18, but did not remain so for a long period, the winter proving to be an unusually mild and open one. During all the period of operations the river stood at an unusually low stage, a condition most unfavorable for work; the use of dump-scows was impossible, and the only course to follow in dredging was to open a channel through the bars, casting the excavated material in a bank beside the cut, with the design of removing it when the water should rise to a sufficient height; the scows engaged in transporting material for the dams could take but small loads, and in many cases they could not even then be conveniently placed beside the dam.

There are many sunken logs and snags in various parts of the river, which, being dangerous obstructions in periods of ordinary low-water, proved more than usually destructive during this season; the new tow-boat, running on one of them, was sunk and had to be hauled out for repairs; on another 4 large barges were sunk, one of them being a total loss. Accordingly, I had one of the scows rigged with the necessary shears and grapples, and organized a force to remove the worst ones along the navigable channel; these operations were in progress during a part of October and November.

During the winter's suspension many repairs and modifications were made to the outfit, the principal work being on the dredge and tow-boat; these were required for giving increased strength, or for obtaining better facilities for carrying on the work, and were the result of experience gained during the preceding working season.

Dredging was resumed March 23, 1880, and was continued until the close of the fiscal year; since the resumption no work on the dams has been practicable owing to high-water.

The following is a summary of the work done (exclusive of that applied to the construction and repairs of machinery) during the year:

DREDGING.

	Cubic yards.
At Pearl Shoals	28,606
At Fisher's Island Bar	46,902
At Atwell's Bar	9,415
At Silver Creek Bar	25,314
Total	110,237

BRUSH AND STONE DAMS.

	Cubic feet.
At Pearl Shoals	98,250
At Fisher's Island Bar	110,389
At Atwell's Bar	42,943
At School House Bar (repairs)	2,524
Total	254,106

The aggregate length of dams at Pearl Shoals and Fisher's and Atwell's Bars, built during the year, is 5,858 feet.

SNAGGING.

The total number of snags and sunken logs removed from the channel was 84, distributed at different localities, as follows:

At Silver Creek, 2; at Apple Creek, 1; at School House Bar, 3; at Fisher's Island Bar, 2; at Spar Island Bar, 9; at Pearl Shoals, 3; below Grand Pass Bridge, 6; McKee's Creek to Naples, 20; at Meredosia Island Bar, 1; at Meredosia Bridge, 1; at Crooked Creek, 2; at Beaver Dam Bar, 1; at Sugar Creek, 12; at Mouth of Sangamon, 2; near Sharpe's Landing, 2; in Bath Chute, 17.

The total cost of this work was $635, or at an average of $7.50 for each snag.

All operations have been carried on by hired labor, and the purchase of material in open market, with the most satisfactory results.

CONDITION OF THE WORK JUNE 30, 1880.

The work of improvement is still far from complete; the bars improved during the past year were the worst remaining on the river, limiting navigation during the low-water period to a draught of 2 feet; as a result of the work done, from 4 feet to 5 feet can be carried in these places at low-water, and that is more than can be carried through the intervals between these bars, and at many other parts of the river.

The length of river covered by our operations during the year does not exceed 8 miles—leaving the snagging out of consideration—but the resulting benefits reach much further—as the greatest obstruction to navigation on this river, below Naples, has been removed; and Naples is the terminus of one of the regular packet-lines from Saint Louis.

The outfit for carrying on operations, as heretofore, consists of 1 dredge, 1 tow-boat, 1 steam-scow, 3 dump-scows, 2 deck-scows, 1 flat-boat, 2 yawls, 1 steam-launch, 1 office quarter-boat, and 1 ordinary quarter-boat, all in good serviceable condition.

PROPOSED APPLICATION OF FUNDS AVAILABLE.

The amount available June 30, 1880, was $148,699.45, of which $110,000 was appropriated by the act approved June 14, 1880, and $38,699.45 is the balance of the previous appropriation.

My project for work under the new appropriation was submitted June 26, 1880, as follows:

The act specifies that the sum of $10,000 shall be applied to dredging. Accordingly it is proposed to apply this amount to operating the dredge and machinery owned by the United States, and to constructing the auxiliary dams and dikes required for the maintenance of the dredged channels. This is in continuation of the present plan of operations which has been sanctioned by previous appropriations by Congress. It is necessary, from the nature of the project, that we carry on all work under this head by hired labor and the purchase of material in open market.

The conditions of the present bill further require that the "sum of $100,000 shall be expended on locks and dams"; therefore it is proposed to apply the amount specified to that purpose.

For completing the slackwater improvement of the Illinois River, two plans are before the department: First, that presented by the Board of Engineers in 1868, which involves the construction of three locks and dams, below Copperas Creek Lock; and second, that proposed in my reports of August 30, 1878, and of May 10, 1880, which involves the construction of two locks and dams.

Local examinations and surveys are necessary for determining the sites for the works, under either plan, and I would propose that these be commenced as soon as practicable. Having fixed upon the sites, detailed plans and estimates may be prepared, and the work of construction commenced. For carrying on the work I would recommend that any dredging that may be required, such as excavating the lock-pit

and approaches thereto, be done by our own machinery, and that the balance of the work be done by contract, after inviting proposals in the usual way. It is probable that with the present appropriation we will be able to contract for building the foundation of one lock only.

The Chief of Engineers, in approving this project, directs that—

No portion of the sum of $100,000 to be applied to locks and dams, except so much as is necessary for surveys, &c., in connection with the preparation of a scheme for improvement by that method, shall be expended until the project therefor has been submitted and approved.

In submitting plans for lock and dam construction, plats showing the area and amount of land required in the permanent service of the locks should be furnished. Any additional land required temporarily during their construction may probably be rented, and thus render purchase unnecessary.

The necessary surveys will be commenced as soon as practicable after the river has receded from its present high stage.

With the balance of last year's appropriation, and $10,000 from the new, the work of dredging will be continued, with such modifications in its details as the commencement of the slackwater system may require. One more dredge should be added to the equipment, for the reason that a single dredge cannot furnish constant work for the tow-boat, nor accomplish, until a remote date, the required amount of dredging. It is accordingly proposed to buy or build one during the season, the sum available being ample for this purpose, and for operating all the machinery throughout the year. Though the radical improvement of the river by the slackwater system is inaugurated under the provisions of this year's appropriation bill, a large amount of dredging will still remain to be done, viz, from the river's mouth up to the first lock and dam that will be built (probably near Columbiana, about 30 miles above the mouth), which part of the river, it is believed, can be completely improved by dredging alone; dredging channels through the worst bars and shoals in the slackwater pools, by which the system can be carried out with dams of less height, diminishing thereby the amount of flowage; finally, to remove obstructions that will be brought into the main river by its tributaries.

Having commenced the slackwater system, subsequent appropriations should be made ample for its energetic prosecution and speedy completion; by this course only can the work be accomplished with economy and the results realized within a reasonable period of time. If but two locks and dams are required for the completion (and, as set forth in previous reports, such is my opinion), it would be a great saving in cost, a great convenience in prosecuting the work, and a marked advantage to navigation, if both works could be prosecuted simultaneously. Until the sites are fixed and detailed plans are prepared a precise estimate of cost is impossible, but it may be stated with confidence that each lock, with dam and all accessories and contingencies, will cost between $350,000 and $400,000; the cost of the two built by the State of Illinois (at Henry and Copperas Creek) was $747,747, as stated by Mr. D. C. Jenné, the chief engineer of the Illinois and Michigan Canal, under whose directions these works were constructed.

The sum appropriated by Congress for commencing the work will admit of contracting for the foundations of one lock only; after this is done the coffer-dams and other auxiliary measures for protecting the unfinished work from damage by freshets and ice will have to be maintained at considerable expense until the permanent structures are in condition to take care of themselves.

My own experience with this class of works—which has been quite extended—no less than that of others, has taught me the danger and

risk of excessive cost to which the structure is liable when left in an unfinished state.

For the above reasons, and in order that this much-needed and valuable improvement may be conducted with vigor and economy, I would earnestly recommend that the sum of $500,000 be appropriated for the fiscal year ending June 30, 1882. With this sum the work of dredging can be carried on; both locks, with their accessory works, can be brought nearly to completion, and will be made absolutely safe against damage from natural causes.

As the construction of locks and dams will probably involve questions of acquisition of lands and flowage of private property, it is desirable that Congress should pass a bill by which we may condemn land when necessary, or when it is impossible to agree upon a price, and by which the amounts due to the owners of flowed lands may be determined.

The object of the improvement as carried on up to the present time was to aid navigation by dredging and constructing wing-dams and dikes; the permanent improvement of the river by this plan was not comtemplated, nor was any estimate of cost made, the Board of Engineers having given its opinion in 1867 that it was "doubtful whether any amount of expenditure upon this plan would give an available depth for navigation of more than 4 feet at extreme low-water."

The amount appropriated for the improvement from 1869 to June 30, 1879, was $589,150, of which there had been expended to June 30, 1880, $550,450.55.

The plan of improvement now adopted is the slackwater system, aided by dredging, and the approximate estimated cost of the work is $1,000,000.

Congress has appropriated, by the act approved June 14, 1880, the sum of $110,000, with which to begin the work; no expenditure has yet been made on this plan.

The amount (approximate), exclusive of former appropriations, required for completing the present plan of improvement is $890,000. After completion, the cost of operating the locks, maintaining the works, and removing obstructions that may be deposited in the river will probably aggregate about $12,000 annually. Whether all or a part of this amount is to be derived from tolls or appropriations by the general government will depend on future legislation.

The improvement of the Illinois River, supplemented by the enlargement of the Illinois and Michigan Canal, will establish a reliable and commodious channel of water communication from the Mississippi River to Lake Michigan, at Chicago.

Money statement.

July 1, 1879, amount available	$82,615 97	
Amount appropriated by act approved June 14, 1880	110,000 00	
		$192,615 97
July 1, 1880, amount expended during fiscal year	43,916 52	
July 1, 1880, outstanding liabilities	361 64	
		44,278 16
July 1, 1880, amount available		148,337 81
Amount (estimated) required for completion of existing project		890,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		500,000 00

COMMERCIAL STATISTICS.

In the present condition of the river and the Illinois and Michigan Canal, the commerce over the Illinois is mainly a local one from Saint Louis, Mo., to Peoria, Ill., though canal-boats occasionally pass from Chicago to points on the river below Peoria, and even to Saint Louis. An indication of the extent of this commerce is given by the following statements, compiled from the reports of the secretary of the Merchants' Exchange, Saint Louis, and from that of the Board of Canal Commissioners of Illinois for 1879:

Arrivals and departures of steamboats, and amount of river freight received and shipped at Saint Louis, Mo., in 1879.

	Arrivals.	Departures.	Freight.	
			Received.	Shipped.
			Tons.	*Tons.*
Upper Mississippi River	946	959	221,285	66,990
Lower Mississippi River	851	872	179,400	499,040
Missouri River	132	139	33,800	15,040
Ohio River	179	176	130,785	86,935
Cumberland and Tennessee River	18	16	14,080	....
Illinois River	234	230	109,620	9,140
Totals	2,360	2,392	688,970	677,145

From this it appears that about 10 per cent. of the total arrivals and departures are by Illinois River boats, which will deliver 16 per cent. of the total river freight received at Saint Louis.

STATEMENT OF COMMERCE ON THE ILLINOIS AND MICHIGAN CANAL FOR THE YEAR 1879.

Canal opened March 29, 1879; closed November 20, 1879.

Number of boats running	136
Number of clearances	4,458
Number of miles run	304,191
Number of tons of freight transported	669,559
Amount of tolls collected	$89,064

The Illinois River is in the custom district of New Orleans; the length of section below Copperas Creek lock remaining to be improved is 135 miles: the enrolled tonnage of vessels on the river aggregates about 20,000 tons.

SURVEY OF ILLINOIS RIVER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., May 10, 1880.

GENERAL: I have the honor to submit the following report on a survey of the Illinois River, executed in pursuance of the act of Congress making appropriations for the improvement of certain rivers and harbors, approved March 3, 1879.

The question of a through line of water communication from the Mississippi to Lake Michigan, via the Illinois River, has been before Congress since an early date.

In 1822, the State of Illinois was authorized to make through the public lands of the United States a route for a navigable canal connecting the Illinois River with Lake Michigan, and between that date and 1854 Congress had granted to the State 321,760 acres of land to assist in its construction. The canal was first opened to navigation in

1848, its cost up to that time being $6,409,509.95; since then the State has spent a great deal towards its enlargement and maintenance. In the mean time several surveys, having in view the improvement of the Illinois River, have been made, the first in 1838, by Capt. Howard Stansbury, Topographical Engineers; the next of any considerable importance was made under the direction of General J. H. Wilson, in 1866, the object of which was "to obtain such specific and accurate information in regard to obstructions to navigation in that river as will enable you to submit estimates for its improvement, so that the largest boats navigating the Illinois and Michigan Canal, and steamboats drawing 4 feet of water, will be enabled to pass through the river to Saint Louis during the season of extreme low-water without breaking cargo."

His report on this survey led Congress to direct a more complete survey in 1867 (act approved March 2), the object of which was to prepare plans and estimates "for a system of navigation by way of the Illinois River, between the Mississippi and Lake Michigan, adapted to *military*, *naval*, and *commercial* purposes." This duty was committed to a Board of Engineers composed of General J. H. Wilson and Mr. William Gooding, civil engineer, the latter having been for a long time the chief engineer of the "Illinois and Michigan Canal." The report of this Board was submitted to the Chief of Engineers under date of December 17, 1867, and is published in his annual report for 1868, pages 438 to 468. It recommended that the Illinois River be improved by the construction of five locks and dams, creating thereby a slackwater system with a navigable depth of 7 feet at the lowest stage, from the mouth of the river at Grafton to Utica, 227 miles above; the lock chambers were to be 350 feet long, 75 feet wide, and the estimated cost of the entire work was $1,953,600. To complete the through line to Lake Michigan, an enlargement of the canal was recommended, the estimated cost of this enlargement being, in round numbers, $16,250,000.

No appropriations were made by Congress to carry out the plan of improvement above indicated, but the State of Illinois, in substantial conformity with that plan, has constructed *two* of the proposed locks and dams (viz, at Henry and Copperas Creek), at a cost of $747,747, while the annual appropriations by Congress for improving the Illinois River (aggregating to date $589,150) have been applied mainly to ameliorating its navigable condition by dredging channels through the worst bars, and constructing dikes and wing-dams for contracting the waterway. For a more detailed description of these operations I would respectfully refer to my report dated August 30, 1878 (which was published as House Ex. Doc. No. 81, 45th Congress, 3d session), a copy of which is transmitted herewith.*

The several surveys and reports above referred to give so complete a description of the physical characteristics of the route, and present the arguments in favor of its improvement so forcibly, that it seems unnecessary to extend this report by repeating what has been so fully set forth before; accordingly it is limited to a brief outline of operations on the last survey, and a statement of what is necessary to complete the improvement of the river.

A substantial improvement having been effected from its point of connection with the canal down to Copperas Creek Lock, it was decided to apply the $5,000 allotted for our survey to the remainder of the river, viz, from Copperas Creek to Grafton, where the Illinois empties into the Mississippi.

* See Annual Report of the Chief of Engineers for 1879, Part II, pp. 1572-1585.

Mr. G. H. Hurlburt, assistant engineer, was placed in charge of the work, and, having organized his party, took the field at Copperas Creek, September 22, 1879; subsequently, October 30, 1879, a second party (under the immediate direction of Mr. R. A. Brown, assistant engineer, in local charge of the improvement of the river) was organized, to carry the survey from Grand Pass to Grafton (41½ miles), the object being to expedite the work during the very low stage of the river which prevailed at the time, and insure its completion before winter set in. This party closed its field-work at Grafton, November 8, 1879, and the party under Mr. Hurlburt closed its work at Grand Pass Bridge November 28, 1879, when field-work was suspended. It had been the intention to supplement the survey by a minute examination of the improved river above Copperas Creek, but this was impracticable, owing to the late date at which the survey was completed.

The survey comprised a tranisit line, a line of levels, a continuous series of soundings, and a number of observations for determining the low-water discharge of the river. The length of transit line from Copperas Creek Lock to Grafton is 720,261 feet, or 136½ miles; the total fall at extreme low-water is 21 feet; the minimum low-water discharge, as determined by our observations, was 1,566 cubic feet per second; the aggregate length of lines of soundings is 425 miles; the total number of soundings being 50,732.

Applying the data presented by this survey to the question of improving the river, it seems necessary for us to consider at this time only two systems of improvement, viz: 1st, *dredging and the construction of wing-dams, dikes, &c.*; 2d, the *slackwater system*. By the former, it is my opinion that a low-water channel 6 feet deep and 200 feet wide may be obtained; for this work the following estimate must be regarded as a minimum:

For 6,150,000 cubic yards dredging, at 15 cents	$922,500
For 100,000 linear feet B and S dams, dikes, &c., at $3	300,000
	1,222,500

The time required would depend entirely on the amount of annual appropriations, noting that the dredging alone would furnish work for one dredge with an annual capacity of 125,000 cubic yards for a period of fifty years. The probable effect of establishing channels of the dimensions above indicated would be a more ready discharge of the water which is now held back by the various bars and shoals, from the deep-water reaches above them, and the development of insufficient depth where it is now ample; hence we must expect considerable work in addition to that stated in the estimate, but its extent cannot now be determined. The improvement having been accomplished, subsequent annual appropriations of from $15,000 to $20,000 would be required for its maintenance.

Turning now to the slackwater system, our survey would indicate that by the construction of two locks and dams only, we could secure a reliable channel of navigation, having a low-water depth of 7 feet over the worst portions of the river; the exact locations for these works can be decided upon only after special examinations and surveys, with that object in view, but the upper one should be in the vicinity of La Grange; the other near Columbiana. The cost of these two works, at an outside figure, should not exceed $800,000; to complete the improvement to the mouth of the river would require dredging about 700,000 cubic yards; in addition to this, some dredging would be required in the pools created by the dams, in order to avoid building the latter unnecessarily high.

But the limit of cost for the entire work on this system may be safely placed at $1,000,000. It will be observed that in this project I have departed in a measure from the plan recommended by the Board, which involved the construction of three locks below Copperas Creek, the last one being in the vicinity of Six-Mile Island, near the mouth of the river. My reasons for this are that the river below Columbiana has a depth of less than 7 feet in comparatively few places, and can be permanently improved by dredging, while wing-dams will not be needed on this section; therefore the construction of a lock and dam at Six-Mile Island seems to me unnecessary for the improvement of this section of the river; admitting this, the only question remaining is, whether by two locks and dams we can make the improvement as far down as Columbiana, instead of only to Bedford (about 15 miles above), as planned by the Board; it is my opinion that this can readily be done with the aid of a little dredging through the crests of the worst bars in the pools; slackwater having been created, the dredged channels would probably be permanent, or nearly so; finally, we would, in addition to saving in first cost, save the cost of maintaining and operating one lock and dam, while boats navigating the river would be saved the expense and time of lockage. This plan is the one indicated on the profile, included in the maps of the survey. The locks contemplated in this recommendation are to be 350 feet long and 75 feet wide, being the size originally proposed by the Board, and adopted by the State of Illinois for those already constructed at Henry and Copperas Creek.

I have no hesitation in selecting the slackwater system, aided by dredging, as that which will accomplish the improvement of the river in the best and most economical manner; it is the only system, in fact, that will give results commensurate with the national and commercial interests involved; in recommending this system, I simply repeat the opinions of my predecessors on the work and of all who have studied the question. If it be adopted, however, I would respectfully represent that the work is of a nature demanding appropriations of greater magnitude than any heretofore made; with small appropriations but little progress can be made in any one season, and the unfinished structure must be left exposed to the dangers of freshets and ice; its protection under these conditions, the loss of time during the favorable working seasons, and the outlay for repairing damages which will inevitably ensue, will add greatly to the cost. I would therefore urge that the first appropriation for each lock be not less than $300,000.

The laws of Congress require that reports of surveys of rivers and harbors shall contain "statements of all existing facts tending to show to what extent the general commerce of the country will be promoted by the several works of improvements contemplated by such examinations and surveys." In fulfillment of this requirement it seems only necessary to note that the improvement of the Illinois River, supplemented by the enlargement of the Illinois and Michigan Canal as heretofore proposed, will furnish a reliable and commodious channel of water communication from the Mississippi River to the Northwestern Lakes; by this line the vast Mississippi Valley, and all the country tributary thereto, is brought into direct water communication with Lake Michigan, at the great city of Chicago, with its flood of commerce eastward and westward; the route exists as a practicable one of considerable importance to-day, and the question is simply one of enhancing its value by increasing its capacity to a degree commensurate with the important interests involved.

Other routes have been examined and studied with care, but neither of them occupies so central a position, can be built so soon, and with

such certain results, maintained so economically, nor utilized through so great a part of the year.

Considering this simple statement, the facts so fully set forth in previous elaborate reports, and noting the wonderfully rapid development of the entire Western country, it would seem that nothing further is necessary to indicate "to what extent the general commerce of the country will be promoted" by the contemplated improvement, nor to show how desirable it is that the work should be accomplished with the least delay practicable.

The total amount appropriated for the improvement of the Illinois River from 1869 to date is		$589, 150 00
From which there has been expended $545,909.57, as follows:		
For foundation of Copperas Creek lock	$62, 358 90	
For dredging, wing-dams, &c., including machinery	483, 550 67	
Total enpended	545, 909 57	
Leaving balance available May 8, 1880	43, 240 43	
		589, 150 00

* * * * * * *

I am, very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

E E 4.

RESURVEY OF THE OUTLET TO WOLF LAKE, IN LAKE COUNTY, INDIANA.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., January 2, 1880.

GENERAL: I have the honor to submit the following report on the "resurvey of the outlet to Wolf Lake, Indiana," made in pursuance of the act of Congress approved March 3, 1879. A tracing showing the results of the survey is transmitted herewith.

The question of making a navigable connection between Wolf River and Lake, and Lake Michigan, has been agitated for some years past. An examination with this object in view was made by Maj. D. C. Houston, Corps of Engineers, U. S. A., who submitted his report to the Chief of Engineers under date of November 26, 1873. No special survey was made at that time. In the year following, however, a detailed survey was made by Maj. G. L. Gillespie, Corps of Engineers, U. S. A., in pursuance of the act of Congress approved June 23, 1874. His report was forwarded to the Chief of Engineers under date of December 4, 1874, who transmitted it to the honorable Secretary of War January 4, 1875. It is printed as Ex. Doc. No. 75, part 1, H. R., 43d Congress, 2d session. As this report, with accompanying maps, gives a full description of the surroundings, and is a complete presentation of the whole subject, I would respectfully suggest its consideration in connection herewith.

The part which the government is asked to take by the private parties interested in the construction of a harbor at this place is stated in Major Houston's report as follows: "To do the work necessary *outside* of the shore line." Major Gillespie states that "it is expressly stipulated" in the memorial submitted by the private parties interested that "the aid

of the government is only asked in the work extending from the water line of the lake *into* Lake Michigan, and that the private parties and associates will themselves complete and entirely execute all work south of the water line of Lake Michigan.

Limiting the project on the part of the government to the work above indicated, it will comprise the excavation of a channel from the shore to deep water in the lake, and the construction of piers for its protection.

This may be accomplished by either of the plans shown on the inclosed tracing. The *south* pier (F G) is the same in all; it extends to the 12-foot curve, and is 950 feet long. The *north* pier in the *first* plan (see line H I) is 200 feet from, and parallel to, the former, extends to the 18-foot curve, and is 2,000 feet long. This plan is essentially that proposed by Major Gillespie, modified slightly as to extent and dimensions of piering. In the *second* plan the north pier (see line H K L) is at a distance of 300 feet from the south pier, to which it is parallel most of the way from the shore for a distance of about 1,300 feet; then the direction is changed, so as to shelter the harbor more effectually against northeasterly storms, which are the most severe in this portion of the lake. The total length of the north pier on this plan from the shore to the 18-foot curve is also 2,000 feet.

Confining our attention for the present to these two plans, the south pier may be limited in width to 12 feet throughout its entire length. On the first plan the north pier should be 16 feet wide from shore to the 12-foot curve, a distance of 900 feet; thence to the 15-foot curve, a distance of 500 feet, it should be 20 feet wide; and the remaining 600 feet to the 18-foot curve should have a width of 24 feet. On the second plan, this pier would be the same as the above out to the 12-foot curve; thence to the angular point, a distance of 400 feet, it should be 20 feet wide, and from that point to the 18-foot curve, a distance of 700 feet, it should be 24 feet wide.

The amount of dredging between the piers out to the 15-foot curve, would be 75,000 cubic yards for the first, and 100,000 cubic yards for the second plan.

The cost of the work above indicated, based on prices now current, and with appropriations sufficient to complete it in two working seasons at the most, is estimated as follows:

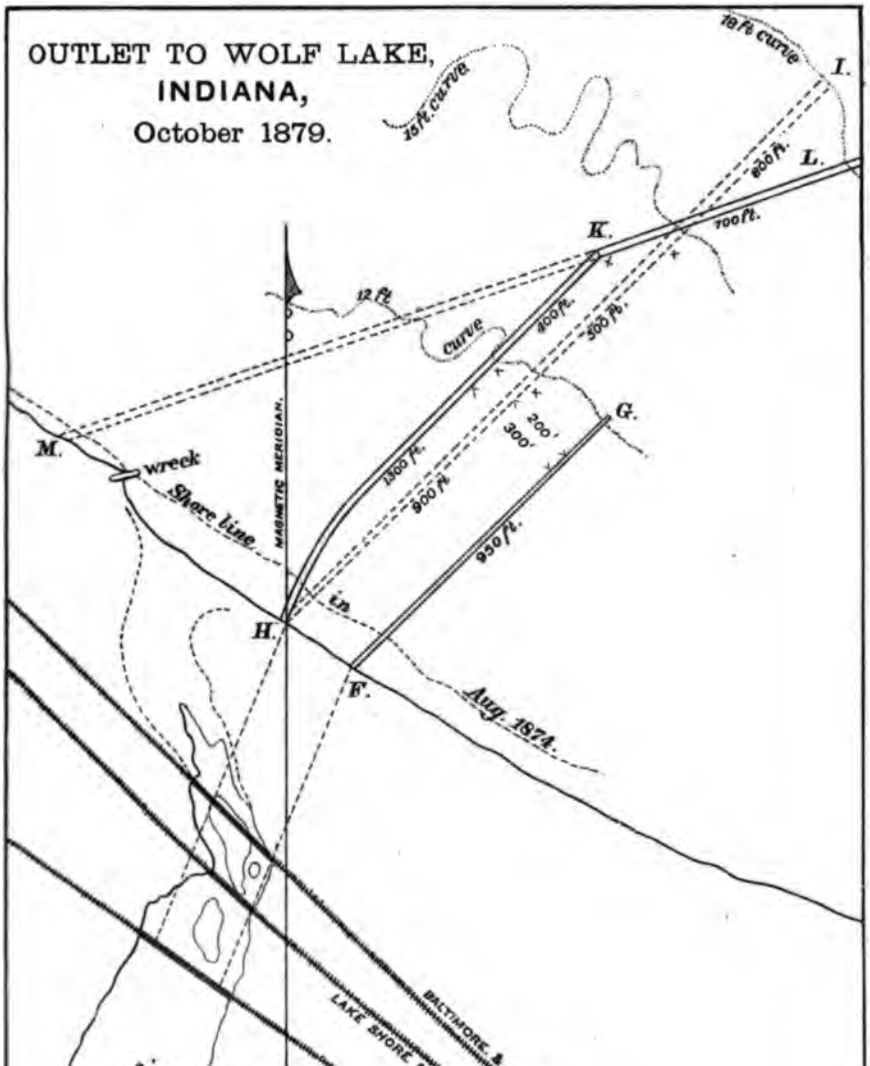
FOR THE FIRST PLAN.

950 linear feet piering, 12 feet wide, at $30	$28,500
900 linear feet piering, 16 feet wide, at $40	36,000
500 linear feet piering, 20 feet wide, at $55	27,500
600 linear feet piering, 24 feet wide, at $65	39,000
75,000 cubic yards dredging, at 20 cents	15,000
Contingencies	10,000
Total	156,000

FOR THE SECOND PLAN.

950 linear feet piering, 12 feet wide, at $50	$28,500
900 linear feet piering, 16 feet wide, at $40	36,000
400 linear feet piering, 20 feet wide, at $55	22,000
700 linear feet piering, 24 feet wide, at $65	45,500
100,000 cubic yards dredging, at 20 cents	20,000
Contingencies	10,000
Total	162,000

No account is taken in either of these estimates of the cost of work thin the shore line, presuming that this would be done by private inrests. It would involve dredging about 200,000 cubic yards, and the



OUTLET TO WOLF LAKE,
INDIANA,
October 1879.
15 ft. curve
18 ft. curve
12 ft curve
I.
L.
K.
G.
M.
H.
F.
800 ft.
700 ft.
400 ft.
500 ft.
200'
300'
1300 ft.
900 ft.
950 ft.
wreck
Shore line in Aug. 1874.
MAGNETIC MERIDIAN.
BALTIMORE & OHIO R.R.
LAKE SHORE & MICHIGAN SOUTHERN R.R.
PITTSBURG & FORT WAYNE R.R.
WOLF RIVER.
INDIANA BOULEVARD
Scale: 1 inch = 500 ft.

S. Ex. 71

construction of a substantial revetment on the sides of the cut. If the government makes any expenditure towards the construction of a harbor at this place, the work done by private parties should be in accordance with plans to be approved by the Engineer Department, which should be duly authorized to enforce compliance with such approved plans.

Of the two projects described above, the second, in my opinion, is the better. The northeasterly seas driving in between the piers, located as in the first instance, would seriously impair the value of the harbor, even to the extent of making it, at times, untenable for vessels; the effect of such seas would be felt for a considerable distance inland. The second project obviates this difficulty to a very considerable extent, if not entirely, and at a comparatively insignificant increase in cost. A modification of this plan is also indicated on the tracing by making the north pier continuous on the line L K M; it would cost more than either of the others, as the pier would be 200 feet longer, and it would be necessary to dredge all of the inclosed basin. The annexed sketch illustrates the three plans referred to herein, and will facilitate a comparison of their merits.

The site for the contemplated work is between Michigan City and Calumet harbors, being 32 miles west of the former and 2¼ miles southeast of the latter. A harbor of refuge is *not* needed there. No factories or other industrial establishments have been erected, and there is no local commerce; no opportunity for any in the present condition of affairs. The interests centered there can hardly be regarded in any other light than as speculative at this writing, or, as stated by Colonel Houston in 1873, "its value will depend on developments of the future." It may be stated, however, that this is a fair site for a harbor; a capacious interior basin can easily be made, and at comparatively small expense, by dredging the several interconnecting lakes in the vicinity. It is probable that advantage will be taken of this condition of affairs in due time, and that the expectations of those owning the property or otherwise interested will be realized. The necessity for dredging a channel to deep water in the lake and constructing protecting piers might then become evident.

* * * * * * *

Very respectfully, your obedient servant,

G. J. LYDECKER,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX F F.

IMPROVEMENT OF THE HARBORS OF MICHIGAN CITY AND NEW BUFFALO, LAKE MICHIGAN.

REPORT OF MAJOR JARED A. SMITH, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

(For letter of transmittal see Appendix Z.)

F F 1.

IMPROVEMENT OF OUTER HARBOR OF MICHIGAN CITY, INDIANA.

The work of the year has been done by hired labor and open purchases of material. The purchases of stone and timber were made by first addressing a circular letter to all dealers within a reasonable distance, and obtaining the timber from the lowest bidder, and stone from two parties, owing to the inability of either to furnish it all as required.

At the beginning of the year, the breakwater consisted of 13 cribs, the superstructure being completed over numbers 2 to 12 inclusive: crib No. 1 had its top 4 feet below the water surface, and No. 13 had no superstructure, having been recently sunk. During the summer and autumn crib No. 1 was completed and the superstructure was extended over it, forming one continuous and solid work.

One hundred and forty square hemlock piles were driven and sawed off by a diver, forming the foundations for 5 additional cribs which were subsequently placed and filled with stone. The superstructure was added at once over 6 cribs, making the breakwater complete for a length of 900 feet. A drawing, showing the elevation of the breakwater, and indicating the annual progress for two years, is forwarded herewith on sheet No. 2.

The sinking of crib No. 15 was accomplished under extraordinary circumstances, and I consider the energy of Mr. J. A. Manning, superintendent of construction, as worthy of special notice. I therefore give his own account:

> The crib was started out at 8 o'clock a. m., and at 9.30 was in position to sink. At 10 o'clock it was anchored on the pile foundation, when, without a moment's warning, the wind, which up to this time had been southerly, whipped suddenly to the northwest. * * *
>
> It was useless to try to raise the crib and tow back, even if we had felt really so disposed; and every man connected with the work in any way was set at work handling

stone; we held on the north side of crib until it was impossible for men to handle stone, or even keep their footing; and as we were in danger of losing our scows without gaining anything more on that side, we came in and confined the work to the south side. At this time the sea was breaking up over crib and at times washing completely over the scows, and it was only by placing the tug bow on against the scows that they could be held up against the crib, the tug working all the time at full speed. This we did, but some damage was done to the scow. We held on until 4.30. * * * Before we left, stone weighing 200 to 300 pounds were washed out of the superstructure of cribs 13 and 14, which was 4 feet high. We had the satisfaction of finding the next day, after the worst gale of the season, that the crib remained all right. * * * *

The following account of the effects of a storm while the work was unfinished, is from the monthly report for September, and is of sufficient interest to repeat:

On the 3d of the month a gale was experienced which was more severe than any which had been known since the commencement of the outer-harbor works, and gave the only instance known in which the inner harbor did not afford sufficient protection to enable vessels to lie alongside the quay in the portion which is parallel to the lake shore.

As crib No. 17 had no superstructure, and that over Nos. 14, 15, and 16 was incomplete, and a portion of No. 13 was not planked over, the work was unprepared for so severe a trial, but the trifling damage sustained cannot fail to show the thoroughly substantial character of the work. The five cribs mentioned were emptied of their stone to a depth of 6 to 10 feet, and the freshly-quarried stone remaining in the compartments had been ground together until it resembled bowlders gathered on the seashore. Notwithstanding the great reduction in weight, the work was so strongly framed together that not a timber was lost or broken.

The end crib, No. 17, was pushed bodily inward a distance of 30¼ inches; the east end of No. 16, 28 inches; the east end of No. 15, 16¼ inches; the east end of No. 14, 5⅝ inches; the east end of No. 13, 5⅝ inches. No. 17 was pushed off its bearings and dropped down 1 foot, being supported in that position by the cross-walls resting upon the piles. The southeast corner of No. 16 was also pushed from its bearings, allowing the crib to tilt very slightly inward. * * *

Stone for filling the cribs is expensive, and although a portion of that washed out may be recovered, yet such contingencies add materially to the cost of constructing the breakwater.

There seems no doubt that the weight of the cribs when loaded is sufficient to prevent any sliding on the pile-heads, but as the force of the heaviest seas is sufficient to remove a large part of the stone from the work at any time before the superstructure is completed, an arrangement has been devised for preventing any movement of the cribs when thus lightened.

REPAIRS OF PIER.

Much of the pile work, west pier, was in such condition as to permit the escape of stone, so that in many of the compartments no stone could be seen above or below water. The superstructure also required repairing in many places. Stone could not be spared in sufficient quantity to fill all the empty places, but the end compartments were filled, using 24 cords of stone. Other materials used in these repairs were—

284 linear feet 12 by 12 inch pine timber.
1,254 linear feet 12 by 12 inch hemlock.
16 white-oak piles.
168 linear feet 6 by 10 white-oak waling pieces.
616 pounds drift-bolts.
1,748 pounds screw-bolts and rods.
25 pounds spikes.

Owing to the amount of rough weather during the summer of 1879, and the difficulty of obtaining timber as fast as needed, the breakwater could only be extended 300 feet. This left a balance of about $7,000, and, to avoid the experience of last year, it was considered best to ex-

pend the amount in the purchase of timber. Advertisements and specifications were completed and distributed among about 100 manufacturers and dealers in lumber. The bids were for hemlock timber and piles, and were opened May 5. Only three bids were received, viz, A. S. Packard, Covert, Mich.; Oliver O. Staanchfield, Ludington, Mich.; Cutler & Savidge, Spring Lake, Mich. A. S. Packard being the lowest bidder was awarded the contract at $10.75 per M, b. m., for hemlock timber, and $4.50 each for hemlock piles 35 feet long. On the 30th of June there had been delivered under this contract 276,564 feet of hemlock timber and 36 piles, and payment was made therefor, reserving 20 per cent. until completion of contract.

PROJECT FOR THE IMPROVEMENT.

The main features of the present project for an outer harbor were adopted in 1870, but some essential modifications in methods of construction have since been introduced as a result of experience, and also some unimportant changes in the plan.

The amount estimated in last annual report for completing existing project was	$126,175
Appropriated June 14, 1880	40,000
Balance required	86,175

It is urgently recommended that the entire amount be appropriated for the year ending June 30, 1882.

The harbor of Michigan City is in the collection district of Chicago.

A request was sent to the collector for a statement of revenue collected, &c., but no reply has been received.

The following statement shows the number of vessels entering the harbor and their freights for the year ending June 30, 1880:

Number of entrances of loaded vessels	703
Amount of lumber received ... feet, b. m.	121,361,687
Amount of shingles received	83,628,150
Amount of lath received	28,317,951
Tons of iron ore received	3,000
Tons of pig iron received	2,500

Money statement.

July 1, 1879, amount available	$42,238 54	
Amount appropriated by act approved June 14, 1880	40,000 00	
		$82,238 54
July 1, 1880, amount expended during fiscal year	37,269 42	
July 1, 1880, outstanding liabilities	627 01	
		37,896 43
July 1, 1880, amount available		44,342 11
Amount (estimated) required for completion of existing project		86,175 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		86,175 00

INNER HARBOR AT MICHIGAN CITY, INDIANA.

At the beginning of the fiscal year a dredge was employed under a special contract with Messrs. U. Culbert & Co. for removing a bar between the piers at the entrance to inner harbor, at 25 cents per cubic yard.

This dredge was employed in the months of July, August, and Sep-

tember removing the bar and other material, to the amount of 21,825 cubic yards.

The dredge operated by the government was kept employed as long as the available funds permitted. It removed in extending the inner harbor 68,277 cubic yards of material.

A bar which formed in March, 1880, near the entrance to inner harbor was removed, the amount of material being 9,010 cubic yards.

This makes a total of 77,287 cubic yards of material removed by the dredge, the entire expense, including towing and all contingencies, being 8.04 cents per cubic yard.

The side cuts have been extended to Sixth street, and the entire width completed to a point above the basin. The progress of this work and condition at the end of the year is indicated on map marked plate No. 1 forwarded with this report.

The cut has been protected in a most substantial manner under direction of the city authorities. This protection forms a quay extending to Sixth street on both sides. The design of this work is shown on plate No. 2. As the dump-scows used for removing material were too old and rotten to be of further service, two good dump-scows have been built. They have a carrying capacity of 110 cubic yards each.

With the appropriation now available for this work it is proposed to extend the harbor, as indicated on plate No. 2, as far as possible, and to remove any bars which may form at the entrance.

Of the amount of $25,000 appropriated for this work there has been expended removing bars and deepening old channel $12,011.90. The necessary surveys, building of dump-scows, and extension of harbor, as shown on plate 1, has been done for the sum of $12,988.10.

As the commerce of the place requires the further extension of this work, an appropriation of $50,000 is recommended for that purpose.

Money statement.

July 1, 1879, amount available	$16,378 35	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$31,378 35
July 1, 1880, amount expended during fiscal year		16,378 35
July 1, 1880, amount available		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 00

F F 2.

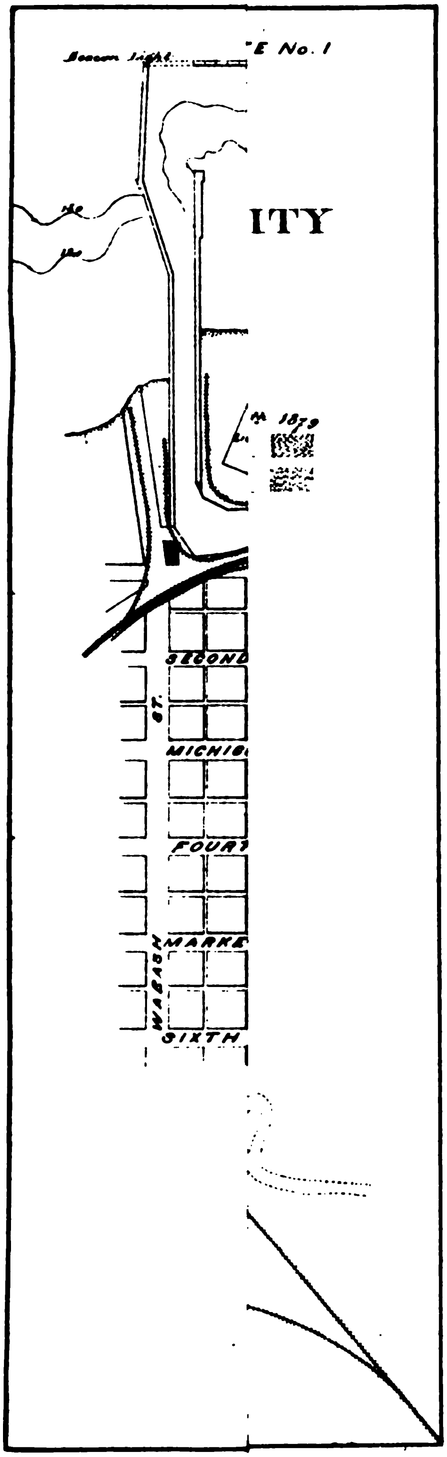
IMPROVEMENT OF NEW BUFFALO HARBOR, MICHIGAN.

There was no work done at this place during the fiscal year.

There has been no appropriation for this harbor since 1872, and none is recommended. A small balance of a former appropriation remains to the credit of the work. As the appropriation was made with a view to making a harbor of refuge in the south end of Lake Michigan, the location being subsequently changed to Michigan City, it is recommended that the remaining balance be made available for the latter location.

Money statement.

July 1, 1879, amount available	$5,000 00
July 1, 1880, amount available	5,000 00


Beacon Light
E No. 1
ITY
1879
SECOND
ST.
MICHIG
FOURT
MARKE
WABASH
SIXTH

APPENDIX G G.

IMPROVEMENT OF HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN—IMPROVEMENT OF SAGINAW RIVER AND OF CERTAIN HARBORS ON LAKE HURON—REPAIR AND PRESERVATION OF SAINT CLAIR FLATS CANAL.

REPORT OF MAJOR FRANKLIN HARWOOD, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., August 24, 1880.

GENERAL: I have the honor to submit herewith my annual reports for the works of river and harbor improvement under my charge during the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

G G 1.

IMPROVEMENT OF CHARLEVOIX HARBOR, MICHIGAN.

This is the northernmost of the works transferred temporarily to my charge by Maj. S. M. Mansfield, Corps of Engineers, October 1, 1879, and of which I relieved him permanently January 12, 1880.

The contract work of 1878, Mr. Hervey S. Dale, of Chicago, contractor, was resumed July 18, and completed on the 30th of August, 1879. Under their contract of June 3, 1879, Carkin, Stickney & Cram, of East Saginaw, Mich., had completed dredging in the channel to the extent of 28,519 cubic yards, all that could be afforded under the appropriation consistently with building up the pier work of their contract, 150 linear feet north pier extension, in a sufficiently secure condition to pass the winter safely. The pier work progressed slowly, and was not closed until the end of November. The superstructure was secure but still incomplete, and as the appropriation was exhausted the contract was closed. No work has since been done.

At the close of the fiscal year, June 30, 1880, the harbor was in the following condition:

Two courses of superstructure and one course of ties remained to be put on the north pier extension of last year, and 85 cords of stone will be required for completing the ballast of this work. A breach threatening the joint of the south pier with the brush jetty at the beach, 50 piles will be driven in prolongation of the channel face of the south pier, secured in line and backed by brush faggots weighted with stone. All of the work above specified will be done by hired labor and material purchased in open market by aid of the appropriation of 1880, the balance of which will be expended under contract as far as it will go in furthering the general project of dredging a channel clear 12 feet in depth, for a width of 50 feet from Lake Michigan to Round Lake. The dredging will be done in the spring of 1881.

At the close of the fiscal year, June 30, 1880, there was a navigable channel of 11 feet depth from lake to lake, but very narrow.

No channel can be maintained after passing within the piers until the banks are properly revetted where such revetment is needed.

This harbor is a comparatively new one, the survey having been made for it in 1868, and three separate estimates have been made for its cost of construction. It has admirable natural facilities, which only need development to make it one of the finest harbors on Lake Michigan. Already the government improvement has stimulated local enterprise, and the Pine Lake Furnace Company have established themselves on the banks of Pine Lake, trusting to the government improvement to give their vessels proper facilities for access to their works. Other industries will doubtless spring up as the work progresses.

The entrance between the piers is now secure, and clear 12 feet of water in the channel of entrance once attained will probably remain without further dredging.

The main and pressing necessity now is to continue that channel to Round Lake, and secure it by the necessary revetments.

The original estimate for these revetments, all of which should be built in one season and as soon as the channel is dredged, was $20,400. This is an item which should certainly be attended to during the working season of 1881; and without entering into details I can confidently state that I can expend to great advantage during the year 1881–'82 at least $50,000 in furtherance of the approved project for the construction of this harbor, having such admirable natural facilities admirably developed so far as the improvement has progressed.

I would propose to apply this sum, under contract, to completing the channel clear 12 feet deep (13 would be better) from Lake Michigan to Round Lake, and to the greatest width admissible within the limit of the natural high banks, which I would revet, where needed to secure the channel, with a plank beam revetment backed by an edging retaining wall as a berme to the bluff which extends for some distance on the south side of the river just after passing the piers of entrance.

The improvement has reached that stage where it would be more economical in the end and highly desirable to afford a large appropriation for one season at least. I therefore ask for $50,000 for 1881–'82, and trust that at any rate not less than $20,000 will be afforded to enable me to at least secure the channel from Lake Michigan to Round Lake.

This work is located in the Michigan collection district, Michigan. It is situated at the mouth of Pine River, which empties into Lake Michigan between Little and Grand Traverse Bays. The nearest port of entry is Grand Haven, Mich. The nearest light-house is at Grand Traverse.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	276
Tonnage	38,476
Cleared:	
Number	280
Tonnage	38,598

Revenue collected, $700.

Original estimated cost of work, 1868	$198,044 14
Amended in 1876	186,000 00
Whole amount appropriated from 1868 to 1880, inclusive	41,000 00
Amount expended	30,938 52
Probable additional sum required for completion of work	145,000 00

Estimated annual expenditure to maintain the harbor: probably none after completion.

Money statement.

July 1, 1879, amount available	$3,426 93	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$13,426 93
July 1, 1880, amount expended during fiscal year		3,365 45
July 1, 1880, amount available		10,061 48
Amount (estimated) required for completion of existing project		145,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		50,000 00

G G 2.

IMPROVEMENT OF FRANKFORT HARBOR, MICHIGAN.

Upon taking temporary charge of this work in October, 1879, I found two contracts for pier extension in force with Mr. Hervey S. Dale, of Chicago, Ill. Under that of August 7, 1878, he had, since June 30, 1879, placed the last crib of his contract in extension of the south pier on July 4, 1879. After permitting it to settle for two months, superstructure was begun upon it September 4 and completed October 9, 1879. Under his second contract of August 16, 1879, to add 50 feet more to the south pier, he built during the month of October, and after great delay, due to the prevailing stormy weather, finally succeeded in sinking in place the cribs on the 10th of November. In the meanwhile the navigation of the harbor was seriously embarrassed by the formation of the outer bar, and as greater depth of water between the piers was also immediately needed to meet the growing necessities of the commerce of the place, the Chief of Engineers concurring, and Mr. Dale consenting, his contract was closed, the United States purchasing from him at cost what material he had accumulated at Frankfort for the completion of his contract. By this measure the United States was placed in funds to open the harbor to commerce in the spring of 1880, with a good channel 13 feet in depth from Lake Michigan to the Frankfort water front.

Upon opening of navigation in 1880, this work was immediately taken in hand, the United States dredging equipment being sent to Frankfort for the purpose, reaching the station March 31, and completing the work June 8, 1880, having cut a channel on the south side of the harbor 75 feet wide, 13 feet deep, and continuous from Lake Aux Becs Scies to Lake Michigan, in all 13,350 cubic yards excavation.

This amount being so much less than anticipated and the outer bar being in a condition to present but little obstacle to navigation, in order to utilize the material purchased from the late contractor, while still in good condition, iron bolts were purchased in open market and this

material worked into superstructure upon the south pier head by day labor, and the work when completed was filled with stone borrowed from the pier where it might best be spared temporarily. Of course this stone must be replaced before the stormy season sets in, and general repairs are also needed on all the piering.

By aid of the appropriation of 1880, this will be done by day labor and material purchased in open market.

Proposals will be advertised for, and contract entered into for completing the channel between the piers. This dredging will probably be done in the spring of 1881, exhausting the appropriation made by act of Congress approved June 14, 1880.

I propose to apply further appropriation to pier extension until the outer bar is crossed, and ask for an appropriation of $20,000 for 1881–'82, to be applied in this manner.

This work is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. The nearest light-house is at Point Betsey (Point Aux Bees Scies). A light is shown near head of south pier.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	202
Tonnage	39,127
Cleared:	
Number	201
Tonnage	38,879

Revenue collected, $256.

Original estimated cost of work 1866, amended in 1875, and again in 1879.	$254,196 43
Whole amount appropriated from 1866 to 1880, inclusive	218,659 85
Amount expended	213,069 21

Probable additional sum required for completion of the work, indeterminate.

Estimated annual expenditure to maintain the harbor, $20,000, in pier extension until the outer bar is crossed.

Money statement.

July 1, 1879, amount available	$6,565 77	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$11,565 77
July 1, 1880, amount expended during fiscal year		5,975 13
July 1, 1880, amount available		5,590 64
Amount (estimated) required for completion of existing project		35,536 58
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

Abstract of proposals received and opened August 16, 1879, for furnishing materials and doing the work of continuing improvements at Frankfort, Mich.

Bidders' names and residence.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Aggregate.
*1. Hervey S. Dale, Chicago, Ill	$0 24	$0 24	$0 03	$0 03¼	$8 00	$2 00	$10 00	$3,716 61
2. Dewar & Corlett, Ludington, Mich	23	50	03	04	9 00	3 00	10 00	3,748 77

*Contract awarded to Hervey S. Dale, the lowest bidder.

G G 3.

IMPROVEMENT OF MANISTEE HARBOR, MICHIGAN.

The contract with Mr. N. Stanton Gere, of Geddes, N. Y., specified in the last annual report, was fulfilled early in October, 1879, just before I took temporary charge of the work. A contract with Mr. Hervey S. Dale, of Chicago, was also in hand for extending the north pier 150 feet and dredging the channel.

Crib framing began immediately on the completion of Mr. Gere's contract, and by the end of October all three cribs were framed and ready for sinking. Persistently boisterous weather prevented this being done, and after waiting patiently for suitable weather for several weeks the contractor finally postponed the placing of the cribs until the spring of 1880. At the close of the fiscal year one crib was in position and filled with stone, and a small amount of dredging had been done in the channel, effecting, however, a complete dredge cut 14 feet deep nearly to the lake. Mr. Dale's contract expires on the 30th September, 1880, when the three cribs will be in place, and all the dredging possible under his contract will be finished, unless circumstances shall arise which may render it advisable to extend the contract to the close of the season.

The scour around the head of the north pier has so deepened the water at that particular point that a large bank of stone has to be built up in foundation, in order to fulfill the provisions of the contract

Stone being the most costly item of the work, the extra expense incidental to preparing these foundations will preclude the possibility of putting superstructure upon the cribs under Mr. Dale's contract. It will therefore be closed, as to pier building, by the sinking and securing of the last crib, the balance of the appropriation being devoted to the dredging.

This great scour at the head of the north pier, which is the farther advanced, is mainly due to the natural current along its line superinduced by the conditions of the channel immediately above the government improvement. Here there is an objectionable re-entering on the south bank which cannot be helped, as the front is private property and permanently improved. The effect of this re-entering is to throw the current over toward the north pier, which is rather a desirable result, if not carried to excess, of which there is danger owing to the protrusion of bulkheads opposite in the north bank beyond the proper port-warden's line. These bulkheads have a tendency to deflect the current so abruptly into the opposite cove as to destroy the natural trend of the river current entirely, and if such building in advance of the proper wharf limit is persisted in the channel below will be seriously interfered with. As the most objectionable protrusion is now a solid, well filled quay fully built up and on private lands, it is presumed that it is beyond government control. Nevertheless I strongly recommend that measures be taken to secure a proper port-warden's line on the north bank of the Manistee River just above the government improvement, in order to prevent further encroachment on the natural course of the river. As the channel now naturally follows and is permanently inclined toward the north pier, I propose to apply future appropriations in extending that pier, adding a pier-head 50 by 30 feet to the south pier and bulkheading it up as a complete work for the present. This latter measure, together with placing the superstructure on the three cribs of Mr. Dale's contract, will exhaust the appropriation of 1880–'81.

I ask for $30,000 for 1881–'82, to be applied to further extension of the north pier and completing the channel 14 feet in depth, now in hand.

This work is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. The nearest light-house is the Manistee light (discontinued October 15, 1875). A light is shown near head of south pier.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	1,687
Tonnage	415,318
Cleared:	
Number	1,691
Tonnage	415,044

Revenue collected, $2,221.

Original estimated cost of the work, 1866, amended 1875	$234,000 00
Whole amount appropriated from 1866 to 1880, inclusive	193,000 00
Amount expended	175,516 20

Probable additional sum required for completion of work, indeterminate.

Estimated annual expenditure to maintain the harbor, $30,000, in pier building to protect the channel until the bar is crossed.

Money statement.

July 1, 1879, amount available	$13,379 94	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$23,379 94
July 1, 1880, amount expended during fiscal year	5,896 14	
July 1, 1880, outstanding liabilities	339 81	
		6,235 95
July 1, 1880, amount available		17,143 99
Amount (estimated) required for completion of existing project		41,771 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		30,000 00

Abstract of proposals received and opened August 16, 1879, for furnishing materials and doing work of continuing improvements at Manistee Harbor, Mich.

Bidders' names and residence.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Dredging, per cubic yard.	Aggregate.
*1. Hervey S. Dale, Chicago, Ill	$0 21	$0 21	$0 3½	$0 03	$7 25	$2 50	$10 00	$0 18½	$11,229 79
2. Carkin, Stickney & Cram, East Saginaw, Mich	20	28	3½	4½	7 00	8 00	10 00	20	11,384 81
3. Squier & White, Grand Haven, Mich	23	30	3	4	8 00	3 00	7 00	17	11,635 26
4. Starke, Smith & Co., Milwaukee, Wis	22	30	3	5	8 50	3 50	7 00	16	11,551 36

*Contract awarded to Hervey S. Dale, the lowest bidder.

G G 4.

IMPROVEMENT OF LUDINGTON HARBOR, MICHIGAN.

When I took temporary charge of this harbor in 1879, the contract specified in the last annual report with Mr. N. Stanton Gere, of Geddes, N. Y., was just completed, and work under the pending one with Dewar & Corlett, of Ludington, to extend each pier 50 feet had just begun. Crib framing was prosecuted until the close of the working season, and resumed in the spring, and at the close of the fiscal year both cribs were in position and filled, not without some delay and expense to the contractor by reason of the north pier crib being moved out of position by the swell of a passing steamer, when just sunk and having little ballast.

Before replacing the site had to be leveled off, and as no other dredge was available, I placed the United States dredge at the contractor's disposal, he paying her expenses and crew during the time he had her in use.

As it is not advisable to put superstructure over these cribs this year, further extension being in contemplation, I propose, Dewar & Corlett consenting, to close their contract with the securing of these cribs for the winter.

Early in the spring of 1880 some difficulty was experienced by vessels in entering the port of Ludington, the channel being tortuous, and affording barely 10 feet water. At the close of the fiscal year, however, the water had risen so that light-draught vessels could enter without difficulty. This, however, is not a condition of this harbor to meet the necessities of commerce. Ludington is the terminus of the Flint and Pere Marquette Railway, a trunk line; and the necessities of commerce demand a channel of full width between the piers, 16 feet deep, and extending across the bar. The same reasoning I have applied to the similar case of Grand Haven could be equally applied to Ludington, which is also admirably situated for a harbor of refuge. The one solution, to my mind, of the necessities of commerce at such harbors as Grand Haven and Ludington is the construction of exterior breakwaters, at a cost of about $500,000; and I could profitably expend next year at Ludington $200,000 upon such work. The present appropriation will be expended in repairs of piers and channel protection, such dredging as may be necessary in case of emergency next spring, and in pier extension; and if the present project is to be continued, I could profitably expend $30,000 in 1881–'82 in pier extension, general repairs, and any dredging which may be immediately necessary.

This work is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. The nearest light-house is at Big Point Sable. A light is shown near head of south pier.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	1,081
Tonnage	217,548
Cleared:	
Number	1,059
Tonnage	217,605

Revenue collected, $1,384.

The following additional statistics have been kindly furnished by the local agent of the Flint and Pere Marquette Railway:

Commercial statistics of Ludington Harbor, exclusive of custom-house reports:

	Tons.
Imports going over Flint and Pere Marquette Railway	30,774
Exports going over Flint and Pere Marquette Railway	22,127
Imports to Ludington City proper	25,000
Exports from Ludington City proper	295,046
Steamers and propellers calling at Ludington, not entering and clearing	204,000
Total tons, in and out of port	576,947

Original estimated cost of work, 1866, amended 1879	$213,787 07
Whole amount appropriated from 1866 to 1880, inclusive	204,185 00
Amount expended	195,339 51

Estimated annual expenditure to maintain the harbor, $30,000 annually in pier extension until bar is crossed.

Money statement.

July 1, 1879, amount available	$8,881 48	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$16,881 48
July 1, 1880, amount expended during fiscal year	8,035 99	
July 1, 1880, outstanding liabilities	562 16	
		8,598 15
July 1, 1880, amount available		8,283 33

Amount (estimated) required for completion of existing project, indeterminate.
Amount that can be profitably expended in fiscal year ending June 30, 1882. $30,000 00

Abstract of proposals received and opened August 16, 1879, for furnishing materials and doing work of continuing improvements at Ludington Harbor, Mich.

Bidders' names and residences.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Aggregate.
*1. Dewar & Corlett, Ludington, Mich	$0 19	$0 50	$0 03	$0 04	$8 25	$2 00	$8 00	$6,532 18
2. Hervey S. Dale, Chicago, Ill	21	21	3	3½	7 50	2 50	10 00	6,544 57

*Contract awarded to Dewar & Corlett, the lowest bidders.

G G 5.

IMPROVEMENT OF PENTWATER HARBOR, MICHIGAN.

Squier & White, of Grand Haven, Mich., were in course of filling a contract for dredging and pile revetment at this harbor when I took temporary charge of it in 1879. All the dredging requisite to clear a site for the revetment had been done, and the revetment of the north bank of the outlet of Pentwater Lake, near the village of Pentwater was well in hand and progressing rapidly and most satisfactorily and handsomely. I have seen but little work of this character to equal, and none to excel, that done by Squier & White, under this contract. Upon

the approach of winter the work, although nearly completed, was discontinued, the stone ballast not being attainable until spring, when it was prosecuted slowly under many difficulties in procuring stone, and at the close of the fiscal year was still lacking a little of completion, but is finished at this writing.

Vessels do not attempt to load deeper than 9 feet draught in seeking Pentwater, and vessels of that draught have no difficulty in entering the harbor. It is, however, desirable to dredge the channel to permit vessels of 12 feet draught to enter.

As at White River, so in this case, it is useless to do any dredging until the piers are made sand tight, and fences are interposed against the superficial drift. These measures of channel protection are now in hand by aid of the appropriation of 1880, and will exhaust that appropriation. The next measure of improvement will be dredging the channel as above proposed, for which, and to carry on the general project of pier extension, I estimate that $20,000 can be profitably expended in 1881-'82.

The work is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. The nearest light-house is at Little Point Sable. A light is shown near head of south pier.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	269
Tonnage	30, 165
Cleared:	
Number	267
Tonnage	30, 177

Revenue collected, $375.

Original estimated cost, 1866, amended 1873	$192, 020 00
Whole amount appropriated from 1866 to 1880, inclusive	172, 820 04
Amount expended	167, 680 60

Probable additional sum required for completion of work, indeterminate.
Estimated annual expenditure to maintain the harbor, $20,000 in pier extension.

Money statement.

July 1, 1879, amount available	$6, 594 84	
Amount appropriated by act approved June 14, 1880	4, 000 00	
		10, 594 84
July 1, 1880, amount expended during fiscal year	5, 455 48	
July 1, 1880, outstanding liabilities	442 60	
		5, 898 08
July 1, 1880, amount available		4, 696 76
Amount (estimated) required for completion of existing project		20, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		20, 000 00

Abstract of proposals received and opened August 16, 1879, for furnishing materials and doing the work of continuing improvements at Pentwater Harbor, Mich.

Bidders' names and residence.	Pine, per cubic foot.	Elm, 10″ × 12″ per linear foot.	Elm, 4″ × 8″ per linear foot.	Pine piles, per linear foot.	Oak piles, per linear foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Edgings, per cord.	Driving piles, per foot.	Removing slabs, per yard.	Dredging sand, per yard.	Aggregate.
1. Hervey S. Dale, Chicago, Ill	$0 25	$0 23	$0 18	$0 08	$0 09	$0 03	$3 50	$8 50	$0 3½	$0 10	$0 30	$0 20½	$6, 137 86
*2. Squier & White, Grand Haven, Mich	20	35	20	8	12	3	5 00	7 50	1½	14	25	25	5, 325 25

* Contract awarded to Squier & White, the lowest bidders.

G G 6.

IMPROVEMENT OF WHITE RIVER HARBOR, MICHIGAN.

There was no work in progress at this harbor when I took temporary charge of it in 1879. A contract was in force with John S. McCoughey, of Montague, Mich., to extend the south pier 100 feet. Mr. McCoughey got to work in the spring of 1880, and experienced great delay in procuring material for the work. At the close of the fiscal year he had, however, both cribs nearly built, and with due diligence may be able to complete his contract within its limit of time, certainly within the year.

This harbor is greatly subject to obstruction by sand, owing to the leaky condition of the piers and the drift over them.

At the time that the harbor of Grand Haven was nearly blockaded in 1879, I was also obliged to take summary measures to relieve this harbor by scour of propeller wheel driving the sand before it. It is, however, utterly useless to attempt any permanent relief until the piers are made sand-tight. The appropriation for 1880–'81 is therefore being expended by hired labor and material purchased in open market, in overhauling the pile and edging portion of the piering, relaying the edgings caught up on the interior binder, and putting the piers generally in as complete repair as the appropriation will permit.

The catch-sand fences, of various patterns, built on the south beach of this harbor, have all answered their purpose well, and saved the channel from much drift; but the beach having made out beyond them they will be continued to the present shore line, and others built on the north side where needed. The South Haven pattern will be used. These measures of channel protection will exhaust the appropriation.

At the close of the fiscal year vessels drawing 8 feet of water could barely get into the harbor, and it is frequently necessary for propellers in passing in and out to dredge their way with their propeller wheels through the light sand. If the appropriation of 1880 shall suffice to make the piers sand-tight, it will be best to apply the first installment of the succeeding appropriation to dredging the channel. Whatever may be left from that appropriation after a commodious channel of 13 feet in depth is dredged may be applied advantageously to extension of north pier.

By the completion of the McCoughey contract the south pier will be 200 feet the longer, and I can see no reason why at this harbor the piers should not be extended equally.

For carrying on the work as above proposed, I estimate that $30,000 can be profitably expended in 1881–'82.

This work is located in the Michigan collection district, Michigan. It is situated at the White River light-house. The nearest port of entry is Grand Haven, Mich. Revenue collected, $1,414.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	938
Tonnage	127,793
Cleared:	
Number	930
Tonnage	126,750

Original estimated cost 1866, amended in 1873	$220,445 56
Whole amount appropriated from 1866 to 1880, inclusive	208,050 00
Amount expended	197,322 98

Estimated annual expenditure to maintain the harbor, $20,000 in pier extension.

Money statement.

July 1, 1879, amount available	$8,143 83	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$13,143 83
July 1, 1880, amount expended during fiscal year		2,416 81
July 1, 1880, amount available		10,727 02
Amount (estimated) required for completion of existing project, indeterminate.		
Amount that can be profitably expended in fiscal year ending June 30, 1882		30,000 00

ABSTRACT OF CONTRACT.

Contract with John S. McCoughey, of Montague, Mich., for furnishing material and labor in continuing improvements, and construct and place cribs at the harbor of White River, Michigan, dated September 1, 1879, to expire September 30, 1880.

Abstract of contract for each class of material and labor:

I.	Pine timber in place	per cubic foot	21¼ cents.
II.	Oak timber in place	do	21¼ cents.
III.	Drift bolts and spikes	per pound	3 cents.
IV.	Screw bolts and washers	do	4 cents.
V.	Stone, in work	per cord	$7 25
VI.	Brush, in work	do	2 00
VII.	Piles, driven	each	5 00

G G 7.

IMPROVEMENT OF MUSKEGON HARBOR, MICHIGAN.

Upon taking charge of this harbor I found no work in hand, but a contract in force with Dewar & Corlett, of Ludington, Mich., to extend the north pier 50 feet. Work began under this contract in the spring of 1880, and at the close of the fiscal year the crib, 50 feet in length, was in place and nearly filed with stone.

This harbor is in excellent condition as regards the channel of entrance, there being ample water for vessels of 12 feet draught, which ordinarily seek it in the lumber trade, and in such numbers as to make it the first in importance on the coast as regards the number of vessels frequenting it. The narrowness of the entrance, 180 feet between piers, is, however, a great drawback, and is the cause of constant minor damage to the superstructure, and the head gear of colliding vessels in stormy weather. There are several such repairs on hand now to be provided for.

The channel of entrance is also threatened with encroachment by sand drifting over the north pier. By day labor and material purchased in open market, a system of catch-sand fences of the same inexpensive character used at South Haven have been built, and interposed against the drift, and were nearly finished at the close of the fiscal year.

Dewar & Corlett will complete their contract during September, 1880, by putting superstructure on the crib they have in place. With the exception of general repairs, where needed, there will then remain nothing to be done to complete this harbor, excepting the carrying on of the system of pier extension, for which estimate was made in the last annual report.

The appropriation of 1880 will be applied, under contract, to extending the north pier as far as the funds will suffice, and as there is no certainty as to when the outside bar will be crossed, I have asked for $30,000 to be expended in further extension during the years 1881 and 1882.

This being an important harbor, I make larger estimate for it, in order to continue work as rapidly as possible. It is possible that some dredging in the channel may be required, but no necessity for it has yet been developed.

This work is located in the Michigan collection district, Michigan. It is situated at the Muskegon light-house. The nearest port of entry is Grand Haven, Mich. Revenue collected, $4,180.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	4,254
Tonnage	773,686
Cleared:	
Number	4,294
Tonnage	786,955

Original estimate 1866, amended in 1879	$168,901 75
Whole amount appropriated from 1866 to 1880 inclusive	156,500 00
Amount expended	144,583 32

Estimated annual expenditure to maintain the harbor, $30,000, in pier extension.

Money statement.

July 1, 1879, amount available	$7,142 39	
Amount appropriated by act approved June 14, 1880	7,500 00	
		$14,642 39
July 1, 1880, amount expended during fiscal year		2,700 71
July 1, 1880, amount available		11,941 68
Amount (estimated) required for completion of existing project, indeterminate.		
Amount that can be profitably expended in fiscal year ending June 30, 1882.		$30,000 00

Abstract of proposals received and opened August 16, 1879, for furnishing the materials and doing work of continuing improvements at Muskegon Harbor, Michigan.

Bidders' names and residence.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Aggregate.
*1. Dewar & Corlett, Ludington, Mich	$0 20	$0 30	$0 03	$0 04	$8 25	$3 00	$10 00	$3,580 07
2. Joseph Williams, Washington, D. C	42½	38	4¾	5½	7 35	9 86	10 35	....

* Contract awarded to Dewar & Corlett, lowest bidders.

G G 8.

IMPROVEMENT OF GRAND HAVEN HARBOR, MICHIGAN.

Upon taking charge of this harbor in October, 1879, I found minor repairs of piers and revetment in progress, and a contract in force with Mr. Hervey S. Dale, of Chicago, for building superstructure over three cribs (150′) in extension of the north United States pier. Although the weather was uniformly calm nothing was being done, nor had been done, towards the execution of Mr. Dale's contract. He was accordingly summoned to take his work in hand, and having failed to do so after due warning, the Chief of Engineers approving, his contract was canceled at the close of the month, and provision made for carrying on the work by day labor and material purchased in open market.

In the meanwhile a most disastrous state of affairs had supervened. The period of calm weather, so favorable to building, was followed by a series of heavy gales of wind which amassed the outer bar, ordinarily a plateau with from 13 to 18 feet soundings upon it, into a ridge across the mouth of the harbor, barring the entrance to any but light-draught vessels, and admitting them only in calm weather.

While the mouth of the harbor was in this condition, on the 28th of October the passenger steamer Amazon, with a very valuable cargo, stranded at the mouth of the harbor in a gale of wind and became a total loss, all lives, fortunately, being saved. Every effort was made to relieve the harbor from the sand embargo, but it was not until late in November that relief was completely afforded, and the channel over the bar renewed by aid of a hired dredge, the United States dredge and equipment ordered from South Haven for the purpose, and the large tug Welcome, ballasted down and driving the sand before her propeller-wheel. During the month of November, also, the large propeller General H. E. Paine came into the harbor in a gale of wind water-logged, and stranded and went to pieces just inside its mouth. Subsequently the schooner Catchpole, loaded with stone, struck on the wreck of the Paine and bilged alongside of the north pier.

For details of the disasters of October and November, 1879, and the measures taken to keep the harbor open, involving constant effort day and night, and employment of expensive machinery, I respectfully refer to my special report of November 3, 1879, and my monthly report of operations for November, 1879, with reports of Assistant Engineer S. C. Mower and Inspector John Macfie appended.

At the close of navigation in December a narrow channel across the bar, which had been opened, was still maintained.

The continuously boisterous weather, of course, prevented any material progress being made in placing superstructure over the north pier extension, and as a result of three months' constant effort it was only possible to secure the cribs for the winter. The material was, however, prepared and framed for spring work, and on the 30th of June, 1880, the superstructure was completed, excepting stone filling, and there was clear 13 feet water over the bar at any point.

Beside the continued overhauling and backing of interior work with shingle shavings, to prevent drift of sand into the channel, in the spring of 1880 planting of willows to arrest drift of sand was taken systematically in hand, and experiment thoroughly made to ascertain the practicability and efficacy of this measure of improvement.

The plantation of last year having with an exceptional plant here and

there proved a failure, and the alleged cause being that the planting was done too late in the season, Mr. John Macfie, inspector, who had heretofore had the matter in hand, was given *carte-blanche* to plant whenever and whatever he thought best. About 6 acres of sand beach threatening the channel with drift were planted with every variety of beach plant attainable. Some have failed, some show life, but the common osier and the red willow seem to thrive best.

A few experimental cuttings of poplar give remarkably favorable results. The full result of the experiment cannot be ascertained until next year, when it will be reported.

In all, 54,900 plants have been set out, of which from two-thirds to three-fourths give promise of living and eventually thriving.

The disaster to the Amazon, the subseqnent wrecking of several vessels in rapid succession, there being five on the beach behind the north pier at one time, beside two wrecks in the channel and that of the *Amazon* off the head of the south pier, the continued sand blockade lasting nearly a month in the busiest season of the year, all of these causes combined to arouse the commercial interests involved to a sense of the necessity of taking more rapid and effective measures for the improvement of this most important harbor to at least the extent necessary to make it accessible at the season of the year when access is most needed.

The prevailing alarm and discontent of the vessel interest took the customary form of animadversion upon the conduct of the engineering, and a letter from the Hon. T. W. Ferry, United States Senator from Michigan, resident at Grand Haven, complaining of the slowness with which the harbor improvement was prosecuted having been referred to me for explanation, I had the honor to demonstrate that the condition of the pier extension at that time, due to the delinquency of the contractor, whose contract had just been canceled, had nothing to do with the disasters of the season, but that the plain and simple need of the harbor was an adequate appropriation to enable the engineer officer in charge to at least catch up with the advance of the sand and be able to hold it in check, even if money enough were not afforded to get it under entire control.

Subsequently, at the request of the Hon. T. W. Ferry, I was directed to report generally upon the condition of Grand Haven Harbor, and in so doing I submitted my memoir of December 27, 1879, in which I gave in full not only my opinions upon the necessities of the harbor, but also submitted a project for its permanent completion both as a harbor of refuge and the principal commercial port on the east coast of Lake Michigan.

This project proposed to substitute a system of outer breakwaters for the system of pier extension now in hand. No action was taken upon it, but by letter of January 12, 1880, I was further instructed to report the probable cost of pier extension to 16, 18, and 20 feet soundings, respectively, and other measures of protection and repair, all in continuation of the present approved project.

In my report of February 3, 1880, I fulfilled these instructions, and made full estimate as to the probable cost of completing the existing project, asking for $85,000 to meet immediate necessities. Fifty thousand dollars was granted by the act of Congress approved June 14, 1880, which is now about to be applied to extending the south pier until its head shall be opposite that of the north, and to revetting the south bank of Grand River below Grand Haven to stop the abrasion of the banks and constant feeding of sand from them to the outside bar.

In asking for further appropriation, I respectfully recur and call par-

ticular attention to my memoir of December 27, recommending a change of project in the improvement of this important harbor, and giving my reasons for it in full.

I respectfully submit that Grand Haven should not be considered in the category of the other harbors, of greater or less importance, which are now under improvement on the east coast of Lake Michigan. It is the terminus and shipping point of the Detroit, Grand Haven and Milwaukee Railway, and the *entrepôt*, directly or indirectly, of several minor railroad lines. Its maintenance and protection is not to be considered as a matter of local importance only, or even of main importance alone to the commerce of Lake Michigan, or that of the chain of great lakes. The interests of so much of the entire through system of railway traffic of the great Northwest as concentrates at Milwaukee for transhipment via Grand Haven to the East and seaboard are vitally concerned in the maintenance and improvement of this harbor. More than this: from its geographical position on the east coast of Lake Michigan it is admirably situated for a harbor of refuge, and is so called now by courtesy, but the refuge, in a gale of wind, consists in the "Hobson's choice" of taking the risk of a probable wreck at a point accessible to railway lines, and machine and other repair shops, or the still more probable disaster of missing the entrance of some more narrow and isolated harbor, where measures for relief in the event of stranding, and subsequent facilities for repair or rebuilding, are less attainable. Under existing circumstances there is no security for any vessel of over 8 feet draught in attempting to make Grand Haven Harbor in a gale of wind, after the stormy season sets in; for the outer bar will amass as an effective barrier within twenty-four hours during a heavy gale.

This is the state of affairs at present, and I respectfully submit will continue to be the state of affairs unless adequate appropriations are made annually for a few years, to enable the engineer officer in charge to get the sand encroachment, both within and without the harbor, under control. The $50,000 afforded by the last appropriation act will go far toward doing this, but still is not enough to be entirely effective. The immediate necessities of this harbor are great; as great in proportion as the interests involved in its improvement. In my opinion, for the next two years at least, $100,000 a year should be allotted to its improvement, in order to keep it open and secure it against its present danger of sand embargo at every stormy season of the year.

But this is not all; I have no confidence whatever in the system now prevailing on the east coast of Lake Michigan of forming harbors by running out parallel piers into the lake. It is to my mind a make-shift at the best, and false economy in the end. As appropriations now run the engineer officer in charge, as regards most of these harbors, is not even able to keep up with the advance of the sand. It is one everlasting struggle to keep the harbor in existence. A succession of liberal appropriations, no doubt, for any one harbor would enable it to be completed and secured under this system for a series of years. But where is the security in the end? What guarantee is there that the same action of nature which formed the bar at its mouth before improvement will not eventually form another bar at its mouth in its advanced position? The same forces are at work, the same inexhaustible supply of mobile sand is at hand, and nothing whatever has been done to arrest the action of nature so far as the shifting of sand along the shore is concerned. The artificial mouth of the harbor has simply been pushed ahead temporarily beyond reach of this action, and the evil day averted for a few years.

In my memoir of December 27, 1879, I propose a project which I am confident will make the improvement of Grand Haven permanent. I have estimated $300,000 as the amount required to complete the existing project. But this completion, for reasons I have stated, I cannot believe will be permanent.

The project proposed in my memoir of December 27, 1879, which is no experiment, but based on solid engineering experiences, is estimated as costing $539,000, or adding contingencies of fighting the drift of sand from sand dunes up the river, between Grand Haven and Ferrysburg, say $600,000, or double the estimate for cost of the present approved project.

The simple question to be decided, then, is, whether it is better to secure permanent improvement at a large expenditure for a few years or at half the cost secure an equally effective temporary improvement, but liable at any time to require renewal and extension, and probably costing more in the end than the permanent improvement. In other words, shall Grand Haven be made a complete harbor now, within a few years and for all time, or shall it linger on in the category of incomplete works, with a fictitious estimate of amount needed for permanent completion continued from year to year and revised from time to time "ad infinitum?" Under the present system of improvement, by extending parallel piers, there is not a complete harbor on the east coast of Lake Michigan, nor do I believe there ever will be, and while in my annual report I carry on the estimates for permanent completion under existing projects, I have not the least confidence that they will in any case suffice, but will all have to be amended sooner or later by increasing the amounts specified, and continue liable to such amendment as long as the work is kept in hand under the present system.

Work heretefore done at Grand Haven, and that now to be done under the existing appropriation, is equally in furtherance of the present approved project, or the one I propose, but with the application of the present appropriation, or the next at the most, the turning point will be reached. Therefore in proposing an application of the appropriation to be asked for during the fiscal year ending June 30, 1882, I once more respectfully submit my project of December 27, 1879. Under it, after reserving so much as is necessary to complete the interior measures of improvement, I would expend the balance in construction of breakwaters, upon which $200,000 per annum could profitably be expended until completed. I have estimated this amount as the sum which, in any event, can be profitably applied to the improvement of this harbor in 1881-'82, and would apply it as above stated in the event of the approval of my project. If, however, the present project is to be continued, the same amount can be profitably applied upon the completion of the interior measures of improvement specified in my report of February 3, 1880, and to pier extension.

This work is located in the Michigan collection district, Michigan. Grand Haven is the port of entry. It is situated at the Grand Haven lights. Revenue collected, $5,618.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	1,190
Tonnage	383,062
Cleared:	
Number	1,123
Tonnage	386,767

Original estimated cost of work, 1866	$352,770 47
Whole amount appropriated from 1866 to 1880, inclusive	351,866 15
Amount expended	301,648 66

Probable additional sum required for completion of work under existing project (estimated), $250,000; under proposed project, $550,000.

Money statement.

July 1, 1879, amount available	$11,905 43	
Amount appropriated by act approved June 14, 1880	50,000 00	
		$61,905 43
July 1, 1880, amount expended during fiscal year		11,687 94
July 1, 1880, amount available		50,217 49
Amount (estimated) required for completion of existing project		300,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		200,000 00

Abstract of proposals received and opened August 16, 1879, for furnishing materials and doing work of continuing improvements at Grand Haven Harbor, Michigan.

Bidders' names and residence.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Aggregate.
*1. Hervey S. Dale, Chicago, Ill	$0 21	$0 21	$0 03	$0 03½	$7 75	$2 50	$10 00	$6,516 69
2. Dewar & Corlett, Ludington, Mich	21	50	3	4	8 00	3 00	8 00	6,605 94
3. Joseph Williams, Washington, D. C	42½	38	4¾	5½	7 35	9 86	10 35	....
4. Squier & White, Grand Haven, Mich	29	30	3	5	8 25	2 00	5 00	7,893 57

* Contract awarded to Hervey S. Dale, the lowest bidder.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 21.

SIR: I have the honor to acknowledge the reference to this office of the resolution of the Senate of the United States, of the 16th instant, directing the Secretary of War to "transmit to the Senate any supplemental report in his department relating to the condition and improvement of the harbor at Grand Haven, Mich., with such views of its importance and necessity, and recommendations respecting the same, as may be deemed advisable by the department," and to respectfully return the same with the inclosed copy of a report of Maj. F. Harwood, Corps of Engineers, dated February 3, 1880, to which attention is invited.

Major Harwood recommends that the piers be extended to 18 feet water; that the beach, both inside and outside of the harbor, be protected in order to arrest the drifting sand from obstructing its navigation, and that the existing piers be repaired, &c., at a total cost of about $300,000, and considers it imperatively necessary that an appropriation of at least $85,000 be made for the fiscal year ending June 30, 1881.

Major Harwood's recommendations are concurred in.

The growing commerce of Grand Haven and the large interests involved in the improvement and maintenance of its harbor would seem to commend it to the favorable consideration of Congress. The necessity for a harbor of refuge at or near it of a capacity and depth of water to meet the pressing needs of commerce is unquestionable.

In regard to the condition of the harbor, Major Harwood, in a report dated December 27, 1879, says:

The harbor at the mouth of Grand River, Michigan, is at present in its normal autumn and winter condition of imperfect accessibility, owing to the shifting sand-bars opposite the heads of the piers and across the channel, which render navigation exceedingly precarious and positively unsafe excepting in calm weather.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen., U. S. A.

Hon. ALEXANDER RAMSEY,
Secretary of War.

REPORT OF MAJOR F. HARWOOD, CORPS OF ENGINEERS.

IMPROVEMENT OF GRAND HAVEN HARBOR, MICH.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., February 3, 1880.

GENERAL: In obedience to your orders of January 12 ultimo I have the honor to report that the probable cost of pier extension at Grand Haven, Mich., in the manner designated in your letter of instructions will be as follows:

To 16-foot soundings, with a pier width of 24 feet, north pier 600 feet, south pier 800 feet; total, 1,400 feet piering, at $100 per linear foot	$140,000
To reach 18-foot soundings, there must be added to each extended pier 200 feet; total, 400 feet piering, 30 feet wide, at $130 per linear foot	52,000
Total to extend piers to 18-foot soundings	192,000
To reach 20-foot soundings there will be required 350 feet addition to each pier; total, 700 feet, at $135 per linear foot	94,500
Total to extend piers to 20-feet soundings	286,500

To put the piers in perfect repair there will be required—

I. To renew superstructure, over 300 linear feet pile piering, 26 feet wide	$6,500
II. Renewing superstructure, repairing, and reinforcing 400 feet crib piering	10,000
III. Overhauling and refilling revetments at shore ends of both piers	6,000
Total repairs of piers	22,500

Cost of breach protection within and without the harbor, to arrest as much as possible the drift of sand, will be as follows:

I. 1,955 linear feet of pile and edging revetment with stone ballast, 14 feet wide and built partly in deep water, as previously estimated	$40,000
II. 1,250 feet pile and edging revetment 8 feet wide in 12 feet water	10,000
Contingencies of dredging in connection with this improvement are indeterminate, as the sand is encroaching rapidly on the proposed channel line, which I locate to leave same channel-width as at the mouth of the harbor. There will be in expenses of dredging, however, at least 10,000 cubic yards at 20 cents per cubic yard	2,000
III. 5,000 linear feet of catch-sand fence, at 60 cents per linear foot	3,000
IV. Planting 800,000 slips and roots of willow and sand cherry, at $2 per thousand	1,600
Total cost of beach protection	56,600

In my project of December 27, 1879, I omitted to make provision for the removal of two wrecks which partially obstruct navigation between the piers, and which should be removed this spring, as they are the nucleus of a shoal which will seriously encroach on the channel. I had hoped that the owners or underwriters would remove them, but I understand they have been abandoned. The expense of their removal should be added to any project of harbor improvement, and will be about $5,000. In my project of December 27, 1879, I proposed to treat the sand encroachment at Grand Haven by the interposition of covering breakwaters, pushing these breakwaters to completion as fast as possible, and leaving the sand encroachment to be treated afterwards, for the reason that, the breakwaters once constructed, the bar at the mouth of the interior harbor would be no longer a terror to navigation, but could be readily avoided and removed at leisure, and measures to prevent its recurrence adopted and carried into effect year after year as appropriations might be afforded. If, however, the project treated in this report is to be carried into effect, it is of the greatest importance that the sand encroachment itself should be checked at once and as completely as possible during the coming working season. To this end I would respectfully recommend that after the south pier is carried out 200 feet, so as to bring its end opposite the north pier, the balance of whatever appropriation may be available be applied to carrying into effect as far as may be the measures for beach protection indicated in this report, leaving further extension of the piers and their repair, which is not immediately necessary, to future seasons of work. Under the project, then, of continuing the improvement of Grand Haven Harbor by pier extension, I estimate as the amount which can be profitably expended for the fiscal year ending June 30, 1881, as follows:

To extend south pier to bring its head opposite the north, 200 linear feet extension, at $100 per linear foot	$20,000
(NOTE.—The increase in this estimate is due to rise in price of iron and stone.)	
Measures of beach protection as heretofore enumerated	56,600
Removing wrecks in harbor	5,000
Contingencies of dredging and wrecking during working season	3,000
Total, say	85,000

Which sum, under this project, I consider imperatively necessary to be appropriated in one season to place and keep this harbor in a navigable condition. Of course I could profitably expend a greater sum in carrying on the prolongation of the piers *pari passu* to termination in deep water, which, in my opinion, should not be less than 18-foot soundings. The total cost of the improvement upon this basis would be $300,000, including measures of beach protection between Grand Haven and Ferrysburgh, not treated in this report and upon which I have not been able to make a close estimate, owing to the necessity of making report at an early date. They would be of the same nature as those I have herein projected, would cost about $20,000, and are scarcely less necessary than those already specified.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

G G 9.

IMPROVEMENT OF BLACK LAKE HARBOR, MICHIGAN.

Upon taking charge of this work I found the contract with Mr. N. Stanton Gere, of Geddes, N. Y., still in hand, although it had been extended, and the allotted period of extension had expired. I summoned Mr. Gere immediately to finish his contract, but before he could do so I was obliged to summarily close it by exhaustion of the appropriation; the great settling and loss of stone from work completed and paid for, necessitating renewal, preventing me from completing the superstructure over the cribs, one of which was sunk in prolongation of the north pier, the other in that of the south pier.

On the 30th of June, 1880, there was from 8 to 9 feet soundings in the channel, and the piers were in fair condition. Both pier-heads had, however, lost nearly all their stone by settlement in the quicksand at their site.

It is proposed to apply the appropriation of 1880 to putting the piers in complete order, and securing the channel from drift of sand by catch-sand fences.

The commerce of this harbor being very slight, no material damage to general commercial interests would result if the work were closed after putting the piers in order and dredging the channel to 10 feet depth; but if existing project of obtaining and securing a channel of 12 feet in depth is to be continued, $20,000 can be profitably expended during the working seasons of 1881–'82 in pier extension.

This work is located in the Michigan collection district, Michigan. It is situated at the Holland light (pier-head light, near head of south pier). The nearest port of entry is Grand Haven, Mich. Revenue collected, $254.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	157
Tonnage	7,940
Cleared:	
Number	159
Tonnage	7,878

Original estimated cost of the work in 1866	$106,238 04
Whole amount appropriated from 1866 to 1880, inclusive	223,615 13
Amount expended	217,615 13

Reason for excess of cost over original estimate, modification of plans involving additional expenditure.

Probable additional sum required for completion of work, indeterminate. Amount required for entire and permanent completion of work, indeterminate.

Money statement.

July 1, 1879, amount available	$4,193 64	
Amount appropriated by act approved June 14, 1880	6,000 00	
		$10,193 64
July 1, 1880, amount expended during fiscal year		4,193 64
July 1, 1880, amount available		6,000 00
Amount (estimated) required for completion of existing project		31,833 40
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

G G 10.

IMPROVEMENT OF SAUGATUCK HARBOR, MICHIGAN.

No work has been done at this harbor during the past fiscal year.

An examination of the harbor early in 1880 developed the fact that the channel between the piers and mouth of the harbor was in better condition than the channel above.

Accordingly by letter, dated February 28, 1880, I applied for and received authority to suspend pier extension, which was contemplated, and devote the existing balance of appropriation to restoring the channel at the first bend of the Kalamazoo to a depth of 10 feet, and to securing it from further invasion of the sand by catch-sand fences and revetments.

Upon closer examination of the harbor this project was found to be of such magnitude as to make it advisable to wait until the comparatively small balance of appropriation was re-enforced by the appropriation of 1880–'81. This appropriation of $5,000 having become available, proposals have been invited for constructing a portion of the revetment necessary to arrest the encroachment of the sand upon the channel. The revetment will be built in 1881.

The necessities of the harbor of Saugatuck are so great and so varied that it is hard to decide where further appropriation is most needed.

The piers sadly need repairs; the outside bar demands that they should be extended; the encroachment of sand on the channel above calls loudly for revetments and catch-sand fences, to an extent which can only be properly determined as the work progresses; and lastly, but not least important, all of these projected improvements are useless unless dredging is done in the river above to enable vessels making the harbor to reach the landings at the town above.

Under these circumstances I respectfully ask for an appropriation of $20,000 to be expended upon such of the improvements above enumerated as may appear most pressing when the money becomes available, and I also respectfully recommend that a survey of the Kalamazoo River from Saugatuck to its mouth be provided for in the next appropriation bill, to enable me to ascertain more definitely what the real necessities of this harbor are, and where best further appropriation can be applied.

I am convinced that a complete revision of the project of improvement is necessary before further improvement is undertaken to any great extent.

This work is located in the Michigan collection district, Michigan. It is situated at the Kalamazoo light. The nearest port of entry is Grand Haven, Mich. Revenue collected, $600.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	206
Tonnage	30,776
Cleared:	
Number	203
Tonnage	31,083

Original estimate 1866, modified 1869	$86,398 56
Whole amount appropriated from 1868 to 1880, inclusive	110,439 00
Amount expended	102,973 59

Reason for excess of cost over original estimate, modification of project demanding a larger expenditure. Probable additional sum required for completion of work cannot be determined until a resurvey is made. Amount required for permanent completion of work indeterminate at present.

Money statement.

July 1, 1879, amount available	$5,176 55	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$10,176 55
July 1, 1880, amount expended during fiscal year		2,711 14
July 1, 1880, amount available		7,465 41
Amount (estimated) required for completion of existing project		34,058 74
Amount that can be profitably expended in fiscal year ending June 30, 1882		20,000 00

G G 11.

IMPROVEMENT OF SOUTH HAVEN HARBOR, MICHIGAN.

Upon taking temporary charge of this harbor in October, 1879, I found the United States dredge at work in furtherance of the project specified in the last annual report, but before she could make any material progress in dredging the channel her services were imperatively required at Grand Haven for reason specified in my report on that harbor, and she was accordingly towed there as soon as the weather served. The weather was so persistently stormy that she could have effected little or nothing toward making the channel, during this season, had she remained at South Haven.

By letter dated November 3, 1879, I applied for and received authority to suspend that portion of the project which contemplated extending the north pier 100 feet, it being considered more important to check the drift of sand over and through the piers, and dredge the channel to full depth and width, particularly as soundings off the pier heads developed the fact that there was plenty of water at the entrance, and that the outside bar was not formidable. It was also contemplated to rectify the south bank of the channel by a plank beam wall connecting the steamboat landing with the inner end of the south pier. Both of these items of work were advertised for, and bids opened on the 30th of April, 1880; one bid only was received for each class of work, and as owing to recent advances in rates of labor and material it was impracticable to do both, it was decided to give the dredging the preference as most important. Contract was accordingly entered into with Squier & White, of Grand Haven, Mich., to dredge the channel, which dredging is now in progress and will shortly be concluded. By it there will be made a channel about 100 feet in width, with a clear depth of 14 feet.

While this channel was in process of dredging the piers were made sand tight, and 1,949 linear feet of sand-fence, of cheap construction, interposed against the drift of sand over the piers. It is hoped that by aid of this sand-fence arresting the drift and the tight condition of the piers the channel dredged this year may be maintained without further expense.

It is proposed to apply the $5,000 appropriated by act of Congress approved June 14, 1880, to perfecting the interior work by constructing the plank beam wall already projected and deferred, and widening the channel, including the removal of an old submerged slab pier which obstructs a portion of the channel. All this will be done by day labor, and the United States dredge, pile-driver, and equipment.

Judging from the existing state of affairs it is not apparent that further pier extension will be required at this harbor to meet the present neces-

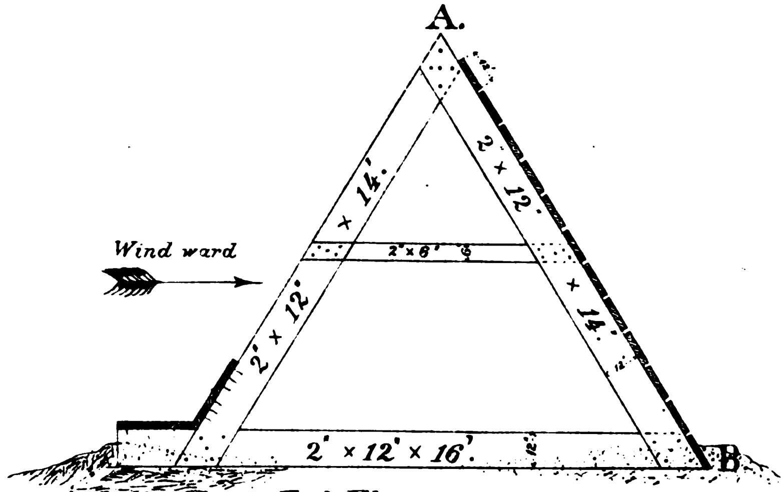
CATCH-SAND FENCE

(Cheap Construction)

SOUTH HAVEN, MICH.

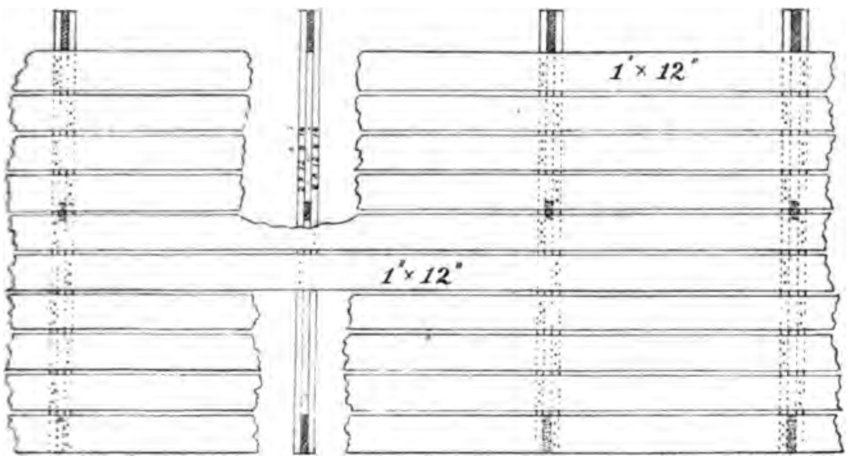
1880.

Scale ¾ inch = 4 feet.



End Elevation

Scale ¾ inch = 4 feet.



Elevation A – B.

sities of commerce. If, however, it is intended to open it and keep it open to 14 feet depth to the lake, it will be necessary to cross the outside bar, over which there is at present about 12 feet soundings. In this case $20,000 can be profitably expended during the year 1881–'82 in pier extension.

This work is located in the Michigan collection district, Michigan. It is situated at the South Haven light. The nearest port of entry is Grand Haven, Mich. Revenue collected, $476.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880

Entered:	
Number	266
Tonnage	30,958
Cleared:	
Number	260
Tonnage	30,955

Original estimated cost of the work in 1866	$128,288 47
Whole amount appropriated since 1866, from 1867 to 1880, inclusive	154,500 00
Whole amount expended	147,319 54

Reason for excess of cost over original estimate has been the large increased expense in pier building during the several years, due to cribs settling deeply in the sand.

Probable additional sum required for completion of the work is contingent on the time of crossing the outside bar, which is shifting at all these harbors, and therefore cannot be estimated. Amount required for permanent completion of work is indeterminate for the reason stated above. Estimated annual expenditure to maintain the harbor, $20,000 can be expended in pier extension.

Money statement.

July 1, 1879, amount available	$10,245 66	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$15,245 66
July 1, 1880, amount expended during fiscal year	8,065 20	
July 1, 1880, outstanding liabilities	425 58	
		8,490 78
July 1, 1880, amount available		6,754 88
Amount (estimated) required for completion of existing project		47,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		20,000 00

Abstract of bids received and opened April 30, 1880, *by Maj. F. Harwood, Corps of Engineers, for the improvement of harbor at South Haven, Mich.*

Bidders' names and residence.	Piles in place, topped, per linear foot.	Pine timber in place, per M feet, b. m.	Pine lumber in place, per M feet, b. m.	Plank (option) in place, per M feet, b. m.	Nut, screw, and washer bolts in place, per pound.	Nails in place, per pound.	Dredging, per cubic yard, measured in scows.	Total for piling.	Total for piling and dredging.
1. Squier & White, Grand Haven, Mich							$0 25		$7,500 00
2. A. D. McDonald, Detroit, Mich	$0 35	$35 00		$32 00	$0 06½	$0 06			
3. George Hannahs, South Haven, Mich	25	25 00	$20 00	13 00	6	6		$3,580 26	3,580 26

Contract for dredging awarded to Squier & White.
A. D. McDonald's bid informal; no bid for pine lumber; no duplicate.
George Hannahs' bid rejected, rates being excessive.

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This work is located in the Michigan collection district, Michigan. It is situated at the South Haven light. The nearest port of entry is Grand Haven, Mich. Revenue collected, $476.

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Bidders' names and residence.	Piles in place, topped, per linear foot.	Pine timber in place, per M feet, b. m.	Pine lumber in place, per M feet, b. m.	Plank (option) in place, per M feet, b. m.	Nut, screw, and washer bolts in place, per pound.	Nails in place, per pound.	Dredging, per cubic yard, measured in scows.	Total for piling.	Total for piling and dredging.
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Contract for dredging awarded to Squier & White.
A. D. McDonald's bid informal; no bid for pine lumber; no duplicate.
George Hannahs' bid rejected, rates being excessive.

G G 12.

IMPROVEMENT OF SAINT JOSEPH HARBOR, MICHIGAN.

Maj. S. M. Mansfield, Corps of Engineers, was in charge of this work, and all others to the northward, on the east coast of Lake Michigan, until October 1, 1879, when I relieved him temporarily, and was afterwards assigned to the permanent charge by letter of the Chief of Engineers, dated January 12, 1880.

Upon assuming temporary charge I found the operations specified in the last annual report nearly completed, great delay having been experienced in procuring stone.

The contractor, Mr. N. S. Gere, of Geddes, N. Y., was urged to immediate and energetic action, which he took, and completed the pier extension October 24, 1879. The United States dredge completed on the 4th of October the work assigned her in giving temporary relief to iron-ore vessels by dredging the outer bar, and was removed to South Haven.

The work upon the wing-dam at the mouth of Benton Harbor Canal, carried on by day labor and material purchased in open market, was completed in September, 1879.

The closing of Mr. Gere's contract having exhausted the appropriation, work was suspended until further appropriation should become available.

The condition of Saint Joseph Harbor proper on the 30th of June, 1880, was excellent, a few minor repairs only being needed for the piers, and there being ample water, not less than 13 feet over the outside bar for all vessels seeking the harbor.

Provision for pier extension, under the appropriation of 1879, had been made by contract with Dewar & Corlett, of Ludington, Mich., to extend the north pier 50 feet; but owing to difficulty in securing timber nothing has yet been done upon the work. All that they will be able to do within the limit of their contract will be to sink and secure the crib; and as it is not desirable to place superstructure over it during the present working season, it is proposed to close their contract when they have the crib sunk and secured in place and properly tied back to the old work.

In the act of Congress approved June 14, 1880, provision was made for the application of so much as was necessary of the appropriation to the improvement of Benton Harbor Canal. This provision meets a crying necessity. While the harbor of Saint Joseph is in excellent condition, and may well wait further improvement for a year or so, the Benton Harbor Canal is so impeded that should low-water supervene, navigation would be well nigh impracticable. Therefore, as soon as the appropriation of 1880 became available, I set the United States dredge, which I had already ordered there for the purpose, to work in dredging the canal in a manner to relieve the immediate necessities of navigation.

I have also, with the approval of the Chief of Engineers, allotted nearly the entire appropriation of 1880 to the improvement of the Benton Harbor Canal, reserving for Saint Joseph Harbor only so much as is necessary for minor repairs and to complete the superstructure over the crib to be laid this year in extension of the north pier.

When the Benton Harbor Canal is properly dredged and protected the village of Benton Harbor will be the shipping point of the produce of a large agricultural region, which is cut off from Saint Joseph by the river, and cannot conveniently reach that harbor.

The necessities of commerce are therefore better subserved, at present, by devoting attention to the Benton Harbor Canal than to the general project of pier extension at Saint Joseph.

I therefore propose to apply the appropriation of 1880 for Saint Joseph Harbor Canal to:

1. Dredging the Benton Harbor Canal, to give 12 feet depth, for 32 feet width, the entire length, with swinging room for vessels at Benton Harbor, $1,800.

2. Revetting the north bank with plank beam at the most exposed points, about 2,500 linear feet of revetment, $5,000, leaving $1,200 for contingencies of repair and completion of superstructure at Saint Joseph Harbor.

The project which I propose for the improvement of the Benton Harbor Canal is—

1. To dredge the canal to a depth of 12 feet, for a width of 80 feet, about 50,000 cubic yards excavation, at 25 cents per cubic yard, $12,500.

2. To revet the north bank with plank beam, a distance of about 3,000 feet, $7,500; total, $20,000, from which deduct $7,000, probably to be spent upon it this season, which will leave $13,000 to complete the project, and which can be profitably expended during the year 1881.

The existing project proposes to continue pier extension at Saint Joseph Harbor until the pier-heads rest in 16-foot soundings.

As the outer bar varies at all these harbors, from time to time, both in contour and position, it is impossible to estimate what length of piering will be required to reach the desired termination.

About 200 linear feet of piering can be conveniently laid under one contract, during a working season, costing about $20,000.

If, therefore, the existing project of pier extension is to be continued, I estimate for 200 linear feet pier extension at Saint Joseph, for the fiscal year ending June 30, 1882, $20,000.

Total estimate for improvement of Saint Joseph Harbor for the year 1881–'82:

Benton Harbor Canal	$13,000
Pier extension, Saint Joseph Harbor	20,000
Total	33,000

This work is located in the Michigan collection district, Michigan. It is situated at the Saint Joseph lights. The nearest port of entry is Grand Haven, Mich. Revenue collected, Saint Joseph, $617, Benton, $524.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 30, 1880.

Saint Joseph Harbor.

Entered:	
Number	277
Tonnage	89,450
Cleared:	
Number	272
Tonnage	89,125

Benton Harbor.

Entered:	
Number	338
Tonnage	98,824
Cleared:	
Number	349
Tonnage	99,521

Original estimated cost of the work as now being carried on	$128,288 47
Whole amount appropriated since adoption of present project, from 1866 to 1880, inclusive	132,000 00
Whole amount expended	120,665 00

Probable additional sum required for completion of the work is contingent on the time of crossing the outside bar, which is shifting at all these harbors, and therefore cannot be estimated. Estimated annual expenditure required to maintain the harbor: $20,000 can be expended in pier extension.

Money statement.

July 1, 1879, amount available	$10,603 57	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$18,603 57
July 1, 1880, amount expended during fiscal year		7,268 68
July 1, 1880, amount available		11,334 89

Amount (estimated) required for completion of existing project, indeterminate.
Amount that can be profitably expended in fiscal year ending June 30, 1882. $33,000 00

Abstract of proposals received and opened August 16, 1879, for material and work for continuing improvements at Saint Joseph Harbor, Michigan.

Bidders' names and residence.	Pine, per cubic foot.	Oak, per cubic foot.	Drift bolts, per pound.	Screw bolts, per pound.	Stone, per cord.	Brush, per cord.	Piles, each.	Aggregate.
Dewar & Corlett, Ludington, Mich.	$0 24	$0 30	$0 03	$0 04	$8 00	$3 00	$10 00	$3,796 67

Contract awarded to Dewar & Corlett, the only bidders.

G G 13.

IMPROVEMENT OF HARBOR OF REFUGE AT PORTAGE LAKE, LAKE MICHIGAN.

The approved project specified in the last annual report was begun in August, 1879, by the construction of brush-mat jetties by day labor and material purchased in open market. The construction of these jetties was carried on until late in the winter and as long as the open weather would permit.

The north jetty was built out to 236 feet length, its head resting in 9 feet soundings, and the south jetty to 190 feet length, its head resting in 8 feet soundings. Twenty-four thousand five hundred bundles of brush and 3,000 stakes were used in this construction.

A constant settling of the work itself in compacting, and also of the entire structure, into the fine sand at the site has rendered it rather expensive, but very complete and satisfactory; so much so, that I should have no hesitation in using it for a foundation for the initial superstructure of the permanent work.

The dredging under contract fell to Carkin, Stickney & Cram, of East Saginaw, Mich., the lowest responsible bidders, and work was begun October 10, 1879, and continued until the lateness of the season forced its discontinuance December 6, 1879.

As a result, a channel 10 feet deep and 135 feet wide was dredged between the old log piers bounding the channel cut by the rushing waters when Portage Lake was let out into Lake Michigan. Twenty-nine thousand nine hundred and ninety-two cubic yards of sand were removed by this dredging, and as the channel was all-sufficient for temporary purposes, and could not be expected to be maintained without protecting works outside, I closed Carkin, Stickney & Cram's contract with the completion of the season's work.

The channel thus dredged filled up of course to a great extent before the spring of 1880, and, therefore, in order to furnish access to the saw-mills now springing up on the banks of Portage Lake under the inducement of the government improvement, after the United States dredge was through with her Frankfort work and relieving the contractor at Ludington, I sent her to Portage Lake in June, 1880, and succeeded in getting one dredge cut through from lake to lake, giving 8 feet depth, just at the close of the fiscal year, when the immediate necessities of Benton Harbor demanding the services of the dredge caused me to suspend this work.

The project for this harbor of refuge proposes a width of entrance of 300 feet. The brush jetties already built would, as I have said, form an admirable starting point for superstructure to be prolonged over the timber piering. These jetties are now 368 feet apart near their present termini and are slightly convergent, so that when, or before, their prolongation would reach 18 feet soundings in Lake Michigan they would attain the prescribed 300 feet interval.

I therefore propose to apply the appropriation of 1880–'81 to converting these brush jetties into permanent work by first bringing their heads opposite in 9 feet soundings and then surmounting them with an edging superstructure top-dressed with stone, the whole retained by rows of piling on either side of the piers and tied across. This I propose to do by day labor and material purchased in open market during the present working season, if possible, and apply the balance of the appropriation under contract to timber pier extension and such dredging as is necessary to keep the existing channel open.

The estimate for the construction of this harbor of refuge is $189,860, of which $10,000 was appropriated in 1879 and $10,000 in 1880. At this rate the harbor will be nineteen years in construction, and, for reasons that I have stated in my report on Grand Haven, it is doubtful if it ever will be completed.

The practical result of operations carried on at the present rate of progress is simply to make a light-draught harbor for the accommodation of the local interests springing up under the influence of its construction. For such a purpose the annual appropriations are in keeping with others afforded for enterprises of like nature now in hand, but I respectfully submit that if this project is to be continued as a national work for the accommodation of the general lake commerce—if it is to be completed within any reasonable period, to meet the necessities of the present generation of shippers, vessel owners and masters—largely increased annual appropriations are imperatively necessary in order to enable the engineer officer in charge to get his work in hand and push it over the ever-accumulating ever-receding bar.

There is not a harbor of refuge on the east coast of Lake Michigan, and the general commerce sadly needs at least one along this long range of dangerous sand bluffs, pierced only at intervals by harbor entrances difficult of access in stormy weather.

While I am confident that I could expend at least $100,000 per

annum to great advantage in constructing a protecting breakwater at some populous point more central with reference to the general coast-line than this isolated location, yet this being an approved project, if it is to be continued at all, I respectfully recommend that it be rapidly pushed to conclusion, as every year's delay adds greatly to the eventual cost of the work. I therefore ask for $100,000 for the year 1881–'82, to be applied to pier extension in furtherance of the existing plan of operations.

Portage Lake is located in the Michigan collection district, Michigan. The nearest light-house is at Manistee. The nearest port of entry is Grand Haven, Mich.

Original estimated cost of work, 1879	$189,860
Whole amount appropriated from 1879 to 1880, inclusive	20,000
Probable additional sum required for completion of the work	169,860

Amount required for entire and permanent completion of the work, indeterminate.

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$20,000 00
July 1, 1880, amount expended during fiscal year		8,954 14
July 1, 1880, amount available		11,045 86
Amount (estimated) required for completion of existing project		170,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		100,000 00

Abstract of proposals received and opened August 16, 1879, for dredging a channel for harbor of refuge at Portage Lake, Lake Michigan.

Bidders' names and residence.	Per cubic yard.	Aggregate.
Hervey S. Dale, Chicago, Ill	$0 23	$5,750 00
O. B. Green, Chicago, Ill	33	8,250 00
Carkin, Stickney & Cram, East Saginaw, Mich.*	14	3,500 00
Starke, Smith & Co., Milwaukee, Wis	16	4,000 00
Squier & White, Grand Haven, Mich	26	6,500 00

* Lowest bidders: contract awarded to Carkin, Stickney & Cram.

G G 14.

IMPROVEMENT OF CHEBOYGAN HARBOR, MICHIGAN.

As proposed in my last annual report, the $3,000 appropriated by act of Congress approved March 3, 1879, was devoted to completing the widening of the river channel opposite the steamboat landings and in completing the removal of the outside bench, which removal would finish the channel according to the original project, with 13 feet depth.

The appropriation being too small to warrant advertising for proposals, I went into open market and got the dredging done at the low rate of 15 cents per cubic yard.

Work was not taken in hand until November, and the exceedingly stormy season prevented any material impression being made on the outer bench. The work of widening the interior channel progressed well until the formation of ice stopped the work. Upon the opening of navigation in the spring the work was renewed, the outside bench removed, and, the appropriation being exhausted, work was suspended, leaving the interior widening of the channel still incomplete. This was partially due to the absolute necessity of removing a shoal which had

formed during the winter in the vicinity of the steamboat landings, and which impeded access to them to such an extent that the Northern Transit Company threatened to withdraw their regular line. This shoal was removed within a few days, and was found to consist mainly of bark and sawdust deposit from the mills above.

I have represented this fact to the village authorities and warned them that no further diversion of government appropriation to meet emergencies caused by mill waste need be anticipated, but that the village will be expected to preserve the channel within village limits. In all 9,843 cubic yards were dredged under the appropriation of 1879, leaving the outer channel complete and but little of the interior widening to be finished.

As the completion of this work was fast approaching, in the autumn of 1879, I had a careful survey made to ascertain the actual condition of the channel made by aid of successive appropriations. This survey was reported in February, 1880, and showed that while in some places the dredging had been irregularly done, still the channel, with an average depth of 13 feet for over 200 feet width, had been obtained.

By aid of the appropriation of 1880, and under contract after inviting proposals in the usual way, it is proposed, while completing the small amount of interior widening of channel still remaining to be effected, to expend the balance of the appropriation in deepening to 15 feet the axial area of the existing channel in the manner and for the reasons specified in my last annual report.

As the cost of dredging has advanced it is hardly probable that this appropriation will suffice to complete this project of deepening the channel along its axis, but it will advance it materially and effectively. To complete this dredging and to extend McArthur, Smith and Company's pier to a pier head in 15 feet soundings, for reasons specified in my last annual report, I estimate $20,000, which, if appropriated in 1881, will probably enable me to complete the improvement of this harbor.

This work is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. The nearest light-house is Cheboygan light. Revenue collected, $1,608,40.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	384
Tonnage	298,748
Cleared:	
Number	384
Tonnage	298,748
Original estimated cost of the work, 1871	$395,000 00
Whole amount appropriated from 1871 to 1880, inclusive	97,000 00
Amount expended	90,874 42

A letter from Deputy Collector Ramsay, in explanation of the commercial statistics of Cheboygan, is appended.

Money statement.

July 1, 1879, amount available	$3,033 05	
Amount appropriated by act approved June 14, 1880	6,000 00	
		$9,033 05
July 1, 1880, amount expended during fiscal year		2,907 47
July 1, 1880, amount available		6,125 58
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, CHEBOYGAN, MICH,
Deputy Collector's Office, July 3, 1880.

DEAR SIR: In compliance with your request, I send you a statement of the business of this port for the fiscal year ending June 30, 1880. The statement is taken from the books in my office and from the receiving-books of the two docks.

Clearances, 384	tonnage..	119,140
Northern transit boats, 269 trips	do....	115,291
Shore lines of steamers, 96 trips	do....	64,317
Total		298,748

During the fiscal year just closed, none of the boats of the Western Transportation Company have called at the port, owing to a lack of a sufficient depth of water to admit them. Many of the Canadian steamers running between lower lake ports and Lake Michigan ports now report at Port Huron, whereas in former years they reported at this office. This reduces the tonnage to that extent, but as the total tonnage this year is just about the same as that of the previous fiscal year, it would indicate a very great increase in the actual business done at this port. As in former years a great many vessels having through clearances have come in and taken on cargoes of lumber, &c., and passed on. I should judge that at least one-half of the lumber forwarded from here was carried in such vessels. The tonnage of these, of course, is not included in the above statement. There should also be added the tonnage of the various craft towing in the harbor and plying on the route from this port to Mackinac and Point Saint Ignace. As you are aware, several of the northern transit steamers failed to call here when bound down, owing to some trouble experienced in the harbor prior to the removal, as per your instructions, of the obstructions. Had these called in, the tonnage, notwithstanding the withdrawal of the boats of the Western Transportation Company, and the Canadian steamers referred to, would have exceeded that of any previous year.

RECEIPTS OF THE CUSTOM-HOUSE.

Duties	$997 43
Entrance and clearance fees	245 40
Hospital dues	170 85
Tonnage tax	61 52
All other sources	133 20
Total	1,608 40

Respectfully, yours.

C. S. RAMSAY,
Deputy Collector.

Maj. F. HARWOOD,
Corps of Engineers, U. S. A.

G G 15.

IMPROVEMENT OF ALPENA HARBOR, AT MOUTH OF THUNDER BAY RIVER, MICHIGAN.

Maj. Godfrey Weitzel, Corps of Engineers, having, in 1875, submitted a project with estimate for improving this harbor by dredging; having received in 1876 an appropriation of $4,500 to do the work; and having, by aid of that appropriation during the working season of 1877, completed the dredging, giving clear 12 feet soundings between the piers, in 1878 the harbor was turned over to my charge as a completed work.

In 1879 I made no report of it, as there was no work in hand and none contemplated. A balance of $561.64 remaining on hand, however, in the Treasury to the credit of this harbor, and it having come to my ears that some shoaling had taken place, and that the commerce of the harbor demanded increased facilities, it was thought prudent to make further examination into its necessities before permanently closing the work. I have accordingly drawn the unexpended balance from the

Treasury, and will apply it this year to making an examination for further improvement. As a result of this investigation, I shall either report for consideration of the next Congress a project for improvement, with estimates, or report the harbor permanently completed.

HISTORY OF THE HARBOR.

In 1864 an association was formed of the citizens of Alpena with a capital of $20,000 to build piers and dredge out the channel of Thunder Bay River at its mouth, where there was 7 feet of water, and at times only 4 feet. This company worked for three years and spent all their capital, and had not been able to get over 9 feet of water, and the stockholders, refusing to advance any more money, the control of the corporation and the harbor was given to one man, Mr. George N. Fletcher, by his paying 50 per cent. of the stock and agreeing to make it a good harbor.

Mr. Fletcher, in the spring of 1869, had secured 11 feet of water.

In 1873 the legislature repealed the act under which Mr. Fletcher had been working, and thenceforward the harbor was considered a national one, and was subsequently improved by the general government, as related elsewhere in this report.

Thunder Bay Harbor is situated in the Port Huron collection district, Michigan. The nearest port of entry is Port Huron, Mich. The nearest light-house is at the mouth of Thunder Bay River.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:	
Number	489
Tonnage	135,872
Cleared:	
Number	503
Tonnage	138,447

Original estimated cost, 1876	$4,764 00
Whole amount appropriated, 1876 to 1880	4,500 00
Amount expended	3,935 36

Probable additional sum required for completion of work; amount required for entire and permanent completion of work; estimated annual expenditure to maintain the harbor; amount that can be profitably expended during the next fiscal year, will be reported after examination is made.

Money statement.

July 1, 1879, amount available	$564 64
July 1, 1880, amount available	564 64

G G 16.

IMPROVEMENT OF HARBOR AND RIVER AT AU SABLE, MICHIGAN.

In furtherance of the approved project for improving this harbor by confining the river near its mouth between revetments so placed as to induce uniform scour in the channel, proposals were invited and bids opened August 20, 1879, and contract awarded to Mr. John R. Worden, of Au Sable, the lowest bidder. Mr. Worden began the construction of the first section of plank beam revetment along the southwest bank of the Au Sable and continued the construction during the working season,

completing all the work on this bank excepting the capping, which was purposely left off in order to permit the beam to settle during the winter.

The difficulty encountered in settling the beam, owing to the piles springing to on a bed of hard gravel, determined the adoption of piles and edging revetment on the opposite bank where there was plenty of room to build back without encroaching on valuable land. Mr. Worden declined, however, to accede to this modification of construction under his contract, but consented that it should be closed with the completion of the revetment of the southwest bank with the plank beam on the Au Sable and Oscoda Village fronts. By a most unfortunate disaster Mr. Worden lost his principal financial backer who was suddenly killed by the bursting of a piece while endeavoring to throw a line to a vessel in distress, and being left without adequate financial support in the spring he was obliged to forfeit his contract. His bondsmen, however, took it up, and, an extension of time having been granted them, will complete their work in August, 1880.

Upon Mr. Worden declining to build on the northeast bank under his contract and the modified project, I invited proposals for the work and received only one, the rates of which being considered excessive, I rejected it, and, having received permission, in the month of June began construction by day labor and material purchased in open market.

In this manner, during the working season of 1880, I shall have completed revetting the northeast bank as far downstream as the Au Sable Bridge. The remainder of the work will be gotten under contract, and by the close of the working season of 1880 I expect to have completely revetted both banks of the Au Sable to the extent specified in my project of 1879, confining the channel within well-defined and continuous limits from the Oscoda Bridge to the lake. This will exhaust both appropriations (1879 and 1880). There will still remain to be done such dredging as may be necessary to get 10 feet soundings in the channel, but it is probable that the natural scour will secure this, excepting where hard gravel bed exists. The banks of the river above, where steep sand slopes are abraded by the current bringing down large quantities of sand to the channel below, must be attended to and revetted with pile and edging retaining walls at their base.

The balance of my revised estimate of 1879, or say rather $12,000, will suffice to do this, and to complete the project, I ask for that amount to be appropriated for 1881–'82. This will complete the interior improvement, but to make the harbor complete other measures of improvement will probably be needed in the event of the formation of a bar, as is most probable, from the sand deposit carried down by the current.

This current will certainly scour out the mouth of the river where the greatest shoaling has heretofore existed, and it is only when after examination I shall have located the bar which must result from the change in conditions of the river current that any intelligent project or estimate to meet the further necessities of navigation at this harbor can be made.

Au Sable River Harbor is situated in the Huron collection district, Michigan, about 14 miles north of Tawas light-house. The nearest port of entry is Port Huron, Mich. Revenue collected not reported.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:

Number	244
Tonnage	59,222

Cleared:

Number	272
Tonnage	66,041
Original estimated cost of work, 1870	$62,880 40
Whole amount appropriated from 1870 to 1880, inclusive	41,000 00
Amount expended	37,219 81

Money statement.

July 1, 1879, amount available	$8,412 36	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$15,412 36
July 1, 1880, amount expended during fiscal year	4,632 25	
July 1, 1880, outstanding liabilities	253 46	
		4,885 71
July 1, 1880, amount available		10,526 65
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		12,000 00

Abstract of bids received and opened August 20, 1879, by Maj. F. Harwood, Corps of Engineers, U. S. A., for the improvement of the harbor and river at Au Sable, Mich.

Bidders' names and residence.	Piles in place, topped, per linear foot.	Pine timber in place, per M feet, b. m.	Plank, select, in place, per M feet, b. m.	Plank, contractor's option, per M feet, b. m.	Screw and washer bolts, per pound, in place.	Cut nails, 30-penny, driven, per pound.
1. Carkin, Stickney & Cram, East Saginaw, Mich	$0 13½	$18 90	$11 50	$11 50	$0 06¾	$0 06
2. John R. Worden, Au Sable, Mich.*	13	13 00	13 00	9 90	6¼	3¾
3. C. Sutherland, South Saginaw, Mich	20	12 00	12 00	10 00	5	3¼

Bidders' names and residence.	Slabs and edgings, in place, per cord.	Hard stone, in place, per cord.	Drift bolts, driving, per bolt.	Spike, driving, per 100 spike.	Pulling piles, per pile.	Total.
1. Carkin, Stickney & Cram, East Saginaw, Mich.	$1 50	$12 15	$0 05	$0 06	$0 95	$10,055 18
2. John R. Worden, Au Sable, Mich.*	75	9 75	7	6	75	8,927 70
3. C. Sutherland, South Saginaw, Mich	2 50	7 00	5	10	1 00	10,643 51

*Contract awarded to John R. Worden, the lowest bidder.

Abstract of bids received and opened April 15, 1880, by Maj. F. Harwood, Corps of Engineers, U. S. A., for the improvement of the harbor and river at Au Sable, Mich.

Bidders' names and residence.	Piles in place, topped, per linear foot.	Pine timber in place, per M feet, b. m.	Pine lumber in place, per M feet, b. m.	Slabs and edgings in place, per cord.	Screw and washer bolts in place, per pound.	Cut spike in place, per pound.	Driving drift bolts, per bolt.	Driving spike, per 100 spike.	Pulling piles, per pile.	Transferring stone, per cord.	Dredging, per cubic yard.	Total for 120 linear feet of work.
1. Carkin, Stickney & Cram, East Saginaw, Mich..	$0 25	$25 00	$19 00	$1 50	$0 12	$0 07	$0 04	$0 25	$1 00	$2 50	$0 35	$842 76

Bid rejected; prices excessive.

G G 17.

IMPROVEMENT OF SAGINAW RIVER, MICHIGAN.

At the beginning of the fiscal year the works in progress for the improvement of this river were in the following condition:

Under contract with Castle Sutherland, of South Saginaw, the construction of a plank beam training wall, to confine the channel at Carrollton Bar, on the Carrollton side of the river, had just begun. Its object and functions are stated in detail in my last annual report. It has fulfilled its object only too well, as the sequel will show. It was finished in August, 1879.

The overhauling and refilling of the Carrollton revetment, under contract with Carkin, Stickney & Cram, of East Saginaw, still lacked a little of completion, but was finished during the month of August, and their contract closed.

At Zilwaukie Bar the wing-dam needed overhauling and refilling, which was done in August by day labor and material purchased in open market.

Snagging the river, under agreement with Castle Sutherland, of South Saginaw, had been in progress, and gave great satisfaction to vessel owners, especially the proprietors of the light-draught ferry-steamers plying between the Saginaws and Bay City. The last clearing was made in the month of July. The result of this experiment has been to show that the river can be kept free from snags at an annual expenditure of about $500; but, in the absence of any law restraining raftmen from cutting loose in the channel water-logged driftwood and stumps caught in their rafts, or refuse logs from the raft, it is not recommended to tax the United States appropriation with an annual expenditure for removing their waste, which is constantly renewing these obstacles to navigation as fast as removed.

Independent, however, of the temporary relief afforded, the expenditure of 1879 has done good and enduring service by effecting the removal of several permanent obstructions, such as sunken trees with roots upturned in the channel, forming a most serious—because hidden—obstacle to navigation. Several of these, vaguely reported, were searched for, found, and removed.

Bids for further channel improvement were opened August 20, 1879, and the award made to Mr. E. H. French, of Fulton, N. Y., for dredging in

the channel to the extent the appropriation would permit. Under his contract Mr. French removed on the East Saginaw front 4,128 cubic yards of sand encroaching on the channel, giving temporary relief; but this stretch of channel can never be secured excepting by a revetment which would interfere with raft navigation. From September 18 to October 15 the dredge was employed on the Carrollton Channel, removing 11,113 cubic yards of sand, and renewing the channel to 100 feet width, with 10 feet depth.

Zilwaukie Bar was then taken in hand, and the channel within the limits of the approved project was nearly finished at the close of navigation when the formation of ice drove the dredge off until the opening of navigation in 1880. Sixteen thousand three hundred and eighty-eight cubic yards of sand were removed at this place. Soundings taken in the spring demonstrated the gratifying fact that the Zilwaukie wing-dam had thoroughly done, and was still doing, the work for which it was designed. Zilwaukie Bar exists no longer, and one great obstacle to navigation in Saginaw River is, I trust, fully and permanently overcome. The scour, superinduced by the wing-dam, during the winter, not only completed unfinished dredging, but cut away the channel in some places to a foot greater depth than was expected to be attained.

There being no further need of its services at Zilwaukie Bar, in the spring of 1880 the dredge was set to work at New York Works Bar, and had nearly completed the project at that point, when, the appropriation being exhausted, contract was closed April 17, 1880, 15,000 cubic yards having been excavated. In all, during the working season of 1879 and the spring of 1880, under Mr. French's contract, 46,629 cubic yards of material were dredged, all of which was dumped behind the middle ground below Crow Island, completely filling that area.

Hereafter all dredgings will have to be thrown behind revetments or above ordinary high-water mark on the river banks, a process which will nearly, if not quite, double the expense.

The same cause which operated to secure such a desirable effect at Zilwaukie Bar operated adversely at Carrollton Bar, and in a great measure obliterated the channel made in 1879. For several years past there has been no material current in the Saginaw River, and when the wind is blowing up Saginaw Bay, not only is the natural flow of the river checked, but sometimes, for days together, there is a perceptible current running toward the source of the river. Of course, under such conditions, no scour can be expected, and even when it does exist, is apt to operate disadvantageously when the current sets up-stream. It had been hoped that a sufficient natural down-stream current would habitually prevail in maintaining a channel once dredged along the Carrollton revetment, but when, after several seasons had elapsed, and the work was completed, it was found that the normal current of the Saginaw River could not be relied on to maintain the channel already dredged, it was decided to fence off the Carrollton Bar with the training wall built in 1879, in order that the channel, confined between the two works, might, at least, not suffer from the drift of sand from off the bar when the current set up-stream. It was expected, however, that the channel would naturally maintain itself along the high revetment which presents its concavity to the river.

With the winter of 1879–'80 came, however, the stage of water so long and anxiously expected and hoped for. There was a positive rise in the river, and for several weeks in the early spring of 1880 a rushing current between the two works at Carrollton Bar. The minor work, the plank beam wall, for economical reasons had been built without dredg-

ing, following the contour of the bar, and at its lower end rising even upon its crest. Thus a large portion of the Carrollton Bar was fenced in toward the channel which was expected to seek the side of the high revetment. But the extraordinary volume of water descending between the two revetments in the winter and spring of 1880 set at naught all ordinary calculations, and changed the entire contour of the river bed between the two works. The channel of 1879, 100 feet wide and 10 feet deep, was converted into one 200 feet wide and averaging 9 feet depth, but blocked at its lower end, where the revetments diverge, with a bar formed by the sand washed down by the current over so much of the Carrollton Bar as was within the plank beam wall. This bar was dredged away sufficiently to offer no further impediment, by aid of a local appropriation under control of a commission at East Saginaw. All that portion of the Carrollton Bar that was contained within the wall has been swept from existence, and there is now a uniform depth of about 8 feet all along the wall where in some cases only about 3 feet existed, and at the upper wing, where the deepest water was 8 feet, there is now 14 feet.

As the piles in the plank beam were only driven to 10 feet penetration in to the bar following its natural contour, it is necessary to re-enforce this upper wing with an edging backing in order to secure it in place. The entire wall has also to be built up along its whole length, having settled bodily under the unexpected scour along it. This is now being done under the appropriation of 1880 by day labor and material purchased in open market.

As soon as this wall is secured and made tight the Carrollton Channel will be restored by dredging, under contract, the sand dredged being thrown over behind the revetment.

The experiences of last winter and the soundings taken this spring show that the natural channel of Saginaw River since the plank beam wall has been placed will not seek either wall but can be best maintained nearly midway between them. A depth of only about 1 additional foot for 100 feet width is needed and will be attained very shortly by dredging under a pending contract.

Under this contract I expect not only to permanently complete the Carrollton Channel, but also to make good progress on the easterly channel at Willow Island, throwing the dredged material over on to the river banks. This will exhaust so much of the appropriation of 1880 as, under the terms of the appropriation act, is permitted to be expended on up-stream work.

I propose, during the coming winter, to make at points where further improvements are projected such examinations as are necessary to determine any revision of existing projects that may appear advisable. I also propose to examine at the same time the river from the Bay City front to its mouth to ascertain what measures of improvement, if any, are necessary along that stretch of river. Upon the results of this examination will depend the application of the $10,000 especially allotted by the terms of the appropriation act to the improvement of this portion of the river, and the allotment will be applied as far as necessary during the working season of 1881. Pending the results of my examinations I adhere to my original estimates and ask for $12,000 in addition to the present appropriation to complete the approved project of improvements between East Saginaw and Bay City. I can profitably expend it in one working season.

This work is located in the Huron collection district, Michigan. The nearest lighthouse is at the mouth of the river. The nearest port of entry is Port Huron, Mich.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1879, TO JUNE 1, 1880.

Entered:

Number	706
Tonnage	205,528

Cleared:

Number	660
Tonnage	188,216

Revenue collected not reported:

Original estimated cost of work, 1874	$56,000 00
Whole amount appropriated from 1874 to 1880, inclusive	96,000 00
Amount expended	81,000 00

Reason for excess of cost over original estimate is given in the annual report for 1877.

Money statement.

July 1, 1879, amount available	$16,703 98	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$31,703 98
July 1, 1880, amount expended during fiscal year		16,703 98
July 1, 1880, amount available		15,000 00
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		12,000 00

Abstract of bids received and opened August 20, 1879, by Maj. F. Harwood, Corps of Engineers, U. S. A., for improving Saginaw River, Michigan.

No. of bids.	Names of bidders.	Residence.	Dredging, per cubic yard.
1	H. T. Stock	Toledo, Ohio	$0 14½
2	Starke, Smith & Co	Milwaukee, Wis	25
3	T. M. Hubbell	Saginaw, Mich	22
4	E. H. French*	Fulton, N. Y	11
5	C. S. Sutherland	South Saginaw, Mich	13

*Contract awarded to E. H. French, the lowest bidder.

G G 18.

IMPROVEMENT OF SEBEWAING HARBOR, MICHIGAN.

The history of the improvement of this harbor is given in the annual report of the late Capt. A. N. Lee, Corps of Engineers, to Maj. Godfrey Weitzel, Engineer officer in charge, who incorporates it in his annual report of 1876. It will be seen by that report that the improvement by dredging to give a channel 6 feet in depth from Saginaw Bay to Sebewaing was undertaken and completed in 1876.

The necessity for a renewal and deepening of the channel is fully set forth in my report of April 21, 1880, giving the results of an examination ordered by Congress under the provisions of the river and harbor act approved March 3, 1879.

The $7,000 asked for in my report, having been appropriated in 1880, will be applied in the spring of 1881 to the fulfillment of the project for which it was furnished, by dredging under contract, after inviting proposals in the usual way. Notwithstanding the late increase in dredging rates, I hope to be able to complete the project within my estimate. Should, however, a few hundred dollars additional be needed, requisition will be made in my next annual report for the necessary amount to complete the project.

Sebewaing is situated in the Huron collection district, and is the last of the harbors in that district upon which I have to report, and I therefore state that for this harbor, as for all others in that district, I have not been able to secure any separate statement of the amount of revenue, it all being accounted for in bulk at the Port Huron custom-house, the amount for the whole district collected during the fiscal year being $36,122.37.

The amount of commerce to be benefited by the improvement is stated as fully as possible in my report of April 21, 1880. The nearest port of entry is Port Huron, Mich. The mouth of the channel is about equidistant from the light-houses at Charity Island and the mouth of Saginaw River. No original estimate was made for this work. The original appropriation was $8,000 in 1875, by aid of which the original project was completed.

Additional estimate 1880	$7,000 00
Whole amount appropriated 1875-'80	15,000 00
Amount expended	8,000 00

Reason for excess of cost over original appropriation is stated in my report of April 21, 1880.

Money statement.

July 1, 1879, amount available	$7,000 00
July 1, 1880, amount available	7,000 00
Amount (estimated) required for completion of existing project	7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	7,000 00

RESURVEY OF SEBEWAING HARBOR, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., April 21, 1880.

GENERAL: In accordance with your circular of instructions of April 25, 1879, I have the honor to report my examination of the harbor of Sebewaing, Michigan, made to ascertain its present condition and the necessity, if any, of further improvement. For a history of previous work at this harbor, I beg leave to refer to the annual report of the late Capt. A. N. Lee, Corps of Engineers, dated July 8, 1876, and contained in Major Weitzel's annual report for the fiscal year ending June 30, 1876.

By correspondence with the Mr. Liken referred to by Captain Lee in his report I surmised, and my examination confirmed my surmise, that the channel dredged by Major Weitzel's direction had not materially shoaled in the lapse of these few years as regarded its entire extent, but I did find that at one or two of the most exposed points the dredged material which had been thrown over in bank had tailed across the channel, and formed as effective a barrier to free navigation as if the whole channel had filled in to the same extent. This was not, however, the main cause of complaint. During the past two years a lower stage of water than usual has ruled in the great lakes and still continues. The effect of this at Sebewaing is to neutralize the improvement effected under Major Weitzel's direction by one foot in draught of vessel. Encouraged by the government improvement completed by Major Weitzel, the citizens of Sebewaing, under Mr. Liken's energetic lead, established new industries

and erected new buildings, a machine and repair shop, sash and blind and hoop factory, and the prosperity indicated in the quotation from Mr. Liken in Captain Lee's report was increasing with the enterprise of the citizens when the stage of low-water supervened, which has thrown a damper upon all their prospects.

Sebewaing had earned for itself the position of principal shipping port for the produce of Tuscola County and the western part of Huron, and was busily engaged in this shipping during the season of navigation; but for the past year it has been, and during this year it will be, necessary to lighter all merchandise shipped to vessels lying in 6 feet water or more beyond the channel dredged by the United States, which is no longer of any material service. As a result, the shops, storehouses, and storage grounds are crowded with produce awaiting shipment, and the tide of prosperity superinduced by the completion of the United States improvement of 1875–'76 is correspondingly checked.

* * * * * * *

The inclosed statement of shipments for the season of navigation of 1879, and general statistics furnished me by Mr. Liken, go to show that Sebewaing, for a light-draught port and small population, is a remarkably active and energetic village.

* * * * * * *

In conducting my examination of Sebewaing Harbor I had two points in view:

1. To ascertain the expense of restoring the improvement of 1875–'76 to its original condition.

2. To ascertain the expense of making such additional improvement as would at the present low stage of water afford the same facilities to navigation as the completed improvement did during the high stage of 1875–'76.

By careful soundings taken through the ice it was found that the channel could be restored to its former condition by dredging 17,000 cubic yards sand and gravel, at a cost, including contingencies, of about $4,000.

To do this would be simply to restore the improvement originally afforded, but it would not give the aid to navigation then intended and effected, neither would it prove even partially effective for any great period of years. The same causes which have induced the present deterioration would induce it again in a few years. If, however, instead of simply restoring the former state of the channel, an additional foot in depth were attained by dredging, in effecting which dump scows also could be used on the work, and at least half of the dredged material removed from the channel entirely and deposited where it could not be washed back, then, indeed, there would be some permanence in the improvement, and the channel, 7 feet in depth—which would after all only afford now the same facilities as the channel of 1875–'76 did then—might be expected to maintain itself for a series of years, and would give such present facilities to the local commerce that the citizens of Sebewaing might be justly expected to look out for their own channel in the future.

* * * * * * *

To simply restore the channel would be money thrown away and wasted in the course of a few years. To dredge a channel 50 feet wide and 7 feet deep to Saginaw Bay, 32,000 cubic yards excavation, at a total cost of about $7,000, would afford ample present facilities to the local commerce and as permanent an improvement as the nature of the case will permit. I therefore estimate $7,000 as the amount required to place the harbor of Sebewaing in a navigable condition, which sum, if appropri-

ated at all, should be granted in one appropriation, as the improvement, to be effective, should be completed during one working season.

Sebewaing is located in the Huron collection district, Michigan. The nearest port of entry is Port Huron, Mich. The nearest light-house is at the mouth of Saginaw River.

The statement of shipments from Sebewaing in the year 1879, heretofore referred to, is appended and marked A, and contains the only commercial statistics I have been able to obtain bearing upon the subject of this examination.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

A.

STATEMENT OF SHIPMENTS, &C., OF MERCHANDISE AT SEBEWAING, MICH., FOR THE YEAR 1879.

Shipments.

115,000 bushels wheat, $1.20	$138,000
10,000 bushels corn, 50 cents	5,000
10,000 bushels oats, 45 cents	4,500
15,000 cedar posts, 5 cents	7,500
40,000 railroad ties, 30 cents	12,000
2,000 cords of wood, $1.75	3,500
2,000 bushels of apples, 50 cents	1,000
50,000 pounds of butter, 15 cents	7,500
3,000 bushels potatoes, 50 cents	1,500
15,000 barrel headings, $1.20	18,000
4,000,000 flour barrel staves, $5	20,000
100,000 white-oak staves, $70	7,000
7,000,000 hoops, $3	21,000
400,000 feet hard-wood lumber, $14	5,600

Imports.

800,000 shingles, $2	1,600
500,000 feet pine lumber	4,000
1,000 barrels of lime	1,000
300,000 laths	450
General merchandise, at least	300,000
Total amount	559,150
500 cords building stone, $7	3,500

Boats regularly plying at this port.

Steamers Liken and Martini, for passengers and freight, forming a daily line.
One tug to do the harbor towing is now building.
Schooners Red Cloud, Lambert, Chappell, Mary, &c.
Barge Hannah B.
Two big lighters to be used in lightering out to vessels and over to Bay City.

G G 19.

IMPROVEMENT OF SAINT CLAIR FLATS SHIP-CANAL, MICHIGAN.

By aid of the appropriation of $5,000, made by act of Congress approved March 3, 1879, I was enabled to secure the head of the west bank by re-enforcing the pile ice breaker with additional piles and binder work and 33 cords of riprap stone thrown in among the piles. The work was completed in November.

During the season of navigation of 1879 some trouble was occasionally experienced by heavily-laden vessels in long tows grounding at the tail of the canal in Lake Saint Clair, being blown on to the flat after coming out from under the lee of the revetted banks before the towing tug or propeller could clear them from the unrevetted cut. Several instances of this kind occurred during the season, and the wheels of tugs and propellers engaged from time to time in extricating these vessels from the bank so disarranged and shoaled the channel in that vicinity that in the spring of 1880 I was obliged to dredge in order to restore the straight line of the channel bank and a uniform depth in the channel itself. I was authorized to go into open market, and hired a dredge from Wilcox Brothers & Stock, of Toledo, Ohio, which, during the latter part of May, and during June, 1880, removed 3,626 cubic yards of material from the channel, giving a uniform depth of 16 feet for nearly the entire width. This necessary improvement, added to that at the head of the canal (the re-enforcement of the ice breaker), together with the salary of the custodian, exhausted the appropriation and left me without funds to make any repair of the embankments, which constantly need refilling at various points. I needed at least $1,500 for this purpose, and had hoped that my requisition for $5,000 for the present fiscal year would have been honored in full.

The appropriation of $2,500 afforded by act of Congress approved June 14, 1880, after reserving the custodian's salary, $1,500, leaves just $1,000 to meet all expenses and contingencies—not enough even to repair the banks, to say nothing of defraying the expense of re-enforcing the head of the east bank, which needs it almost as badly as the west head did last year.

The $1,000 will be applied, as far as it will go, to the repair of the banks, where repairs are immediately neeeded to prevent extended damage. In this connection, I respectfully refer to the project submitted in my last annual report for securing a constant revenue for the maintenance of the canal by a tax on passing vessels. This project, when published, received the almost unanimous condemnation of vessel owners and shippers, and others upon whom the nominal burden of the tax would rest. Nothing, however, was heard from the rest of the tax payers of the United States, who indirectly maintain the canal without directly reaping the benefits to commerce resulting from its existence, as do the persons who are so unwilling to contribute the insignificant sum each would be taxed for its support. Neither have I seen any successful refutation of the argument contained in my last annual report as to the necessity of the existence of some constant source of revenue for the maintenance of the canal. If anything were needed to enforce my argument, the present state of affairs would suffice to confirm it, if, indeed, it is not emphasized during the year by some disaster to the canal banks, irreparable, for the time being, for the lack of adequate funds. Such a breach as that made by the *India*, in 1878, while readily

repaired at the time, if left to stand unrepaired during the stormy season, would result in a gap through the bank and a blockade of the channel within.

The necessity for the maintenance of this canal by a fixed revenue does not seem to have secured the attention the importance of the subject deserves. I therefore respectfully renew my recommendations of last year, to be found on page 1655 of the annual report of the Chief of Engineers, and beg attention to the reasons therein given for the necessity of a constant revenue for the maintenance of this important public work. It is not an unfinished project. The commerce of the great lakes has for years been reaping the benefit of its existence, and notwithstanding their objection to being taxed for its support it is universally acknowledged, by masters of vessels and owners, to be the greatest aid to navigation in existence on the lakes.

I see no reason why the Saint Clair Flats Canal, a completed government work, requiring an almost uniform annual expenditure for its support, should be confounded in the category of the various existing schemes for internal improvements, large or small, of national or local importance. I do not see why it is not to be put on the same footing, as regards support, as the Sault Sainte Marie or Louisville and Portland canals, national works of a similar although more expensive and elaborate character, but built by the general government for a similar purpose. The old channel about the canal is unnavigable to the larger class of vessels passing in long tows as is customary in navigating the Saint Clair River. If such vessels were to use this channel at all they would have to do so singly and with a foot or more less draught than that to which they now load. The Saint Clair Flats Canal is therefore practically a necessity to vessels of this class and a great convenience to all others. Why should they not then be taxed for its support, as they alone directly reap its benefits? Or if direct taxation for its support is so obnoxious, and is not considered advisable, why, as in the case of the Louisville and Portland Canal, should it not as a free work be maintained by draught on the Treasury by the honorable Secretary of War for such amounts as may be necessary, from time to time, to keep it in repair and pay for its maintenance? I earnestly recommend that one or the other of these measures be taken to secure an unfailing support for this most important public work. There has been no year since I have had charge of the canal that it has not needed at least $5,000 for repairs and maintenance. I estimate that amount as necessary for the next fiscal year, and more especially so on account of the large reduction in the appropriation of 1880, which leaves me with my hands tied and my efforts to keep the banks in proper repair seriously crippled. I therefore earnestly trust if Congress does not consider it advisable to put the canal on a basis of stated revenue in either of the ways I have suggested, that at least my requisitions for its support may be honored in full and not scaled down as if it were a work of improvement in progress whose advancement might well be subordinated to the general necessity for reduction in appropriations. I estimate $5,000 for the fiscal year 1881-'82, as not only profitably but absolutely necessary to be expended on the Saint Clair Flats Canal for its proper maintenance and repair.

This work is located in the collection district of Detroit, Mich. The nearest port of entry is Detroit, Mich., but this has no especial bearing on the commercial importance of the work, as the whole commerce of the great lakes is benefited by its existence, and the revenue of every custom-house on the lakes incidentally increased by the facilities it offers as an important cut-off in the great thorougnfare from Lake

Erie to Lake Huron. For revenue statistics, therefore, see general reports of lake custom-houses. There are two light-houses on the canal banks.

Original estimated cost of work, 1866	$428,754 00
Whole amount appropriated from 1866 to 1880, inclusive	592,500 00
Amount expended	588,987 62

Reason for excess of cost over original estimate: Modification of project involving additional expenditure. Probable additional sum required for completion of work: The canal is supposed to be a completed work. Estimated annual expenditure to maintain the canal, $5,000.

Money statement.

July 1, 1879, amount available	$3,888 44	
Amount appropriated by act approved June 14, 1880	2,500 00	
		$6,388 44
July 1, 1880, amount expended during fiscal year		3,764 50
July 1, 1880, amount available		2,623 94
Amount that can be profitably expended in fiscal year ending June 30, 1882		5,000 00

G G 20.

EXAMINATION OF SAINT JOSEPH RIVER, FROM ITS MOUTH, IN MICHIGAN, TO ELKHART, INDIANA, INCLUDING CHANNEL LEADING UP TO BENTON HARBOR.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 14, 1880.

GENERAL: In obedience to telegraphic instructions, I have the honor to report the examination of the Saint Joseph River from its mouth in Michigan to Elkhart, Indiana, including channel leading up to Benton Harbor. This examination was intrusted to Maj. S. M. Mansfield, Corps of Engineers, and the field-work was completed before I relieved him temporarily of his duties, and consequently all report I have to make is based upon examination of the maps and profiles and the data furnished in the elaborate and exhaustive report of Mr. John A. Mitchell, assistant engineer, who made the examination, under Major Mansfield's instructions. For this reason I regret that that officer has not had the opportunity to conclude by his own report the duty originally assigned him. Mr. Mitchell's report is very full, and covers all the ground contemplated in the examination, while his estimates, necessarily approximate, are as close as could be expected under the circumstances, and are probably not far away from the actual expense of the improvements he projects. I therefore respectfully forward it, remarking only that while the improvement of the river from Saint Joseph to Berrien Springs and the canal to Benton Harbor would probably be of benefit to the limited local commerce, the great expense incidental to any adequate and permanent improvement of the river above Berrien Springs would in all probability be totally incommensurate with the limited commerce which might thus be developed, but which does not now exist. It is not apparent that the general commerce of the lakes would be at all benefited by any of these projected improvements, for which closer and more definite estimates should be made of the more careful local examinations before any money is appropriated.

The nearest port of entry to the region of the survey is Grand Haven, Mich., in the collection district of Michigan. The nearest lights are situated at Saint Joseph, at the mouth of the river.

STATEMENT OF VESSELS ENTERED AND CLEARED FROM JUNE 1, 1877, TO JUNE 1, 1878.

Saint Joseph.

Entered:	
Number	257
Tonnage	81,294
Cleared:	
Number	257
Tonnage	82,558

Benton Harbor.

Entered:	
Number	367
Tonnage	89,874
Cleared:	
Number	371
Tonnage	91,427

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. JOHN A. MITCHELL, ASSISTANT ENGINEER.

DETROIT, MICH., *January* 12, 1880.

SIR: I have the honor to submit the following report of a reconnaissance of survey of the Saint Joseph River from Elkhart, Ind., to Saint Joseph, Mich.; also of the ship-canal from Saint Joseph to Benton Harbor. The survey was made under order of Col. S. M. Mansfield, dated August 2, 1879, and in accordance with verbal instructions received from him at that time. Its object was to determine if the stream is capable of being made navigable between the limits stated, and what improvements are necessary to be made to effect its free navigation, and the cost thereof. Also, to obtain such other information as will tend to show to what extent the general commerce of the country will be promoted by the work of improvement contemplated.

In accordance with instructions, I left Detroit on the 2d day of August. At Ann Arbor, Mich., I procured the services of Mr. T. S. McCoy as assistant. On Monday, August 4, I left Ann Arbor, and on the evening of the same day arrived at Elkhart, the point where it was deemed advisable to commence the work. * * *

I was informed that the river was very low, the water being from 6 inches to 1 foot below the usual low-water. I found a daily fluctuation of from 6 to 9 inches in the height of water, caused by the storage of water at the dams above during the night when the mills were idle.

The weather during the month engaged in the survey was free from rain or storms, and consequently, with the above exceptions, the stage of water was very uniform, and my plats of soundings will show the river at its lowest and worst stage for navigation.

The general course of the river from Elkhart to South Bend is westerly. From South Bend to Saint Joseph it flows in a northerly direction. During its whole extent it is sinuous and winding, with many short abrupt bends.

From Elkhart to Berrien Springs its bed is composed of sand, gravel, and cobble-stones, with many large rocks or bowlders. From Berrien Springs to its mouth the bottom or bed becomes more sandy and is more liable to the shifting action of the water. This latter portion of the river I find much obstructed by drift wood in the form of sunken saw-logs, fallen trees, &c. At points between Buchanan and Berrien Springs I find the bottom a bed composed of broken sandstone of sufficient size and tenacity to withstand the action of the current and to cause great obstruction in the channel. The river is composed alternately of pools and ripples. The latter being in length from 100 to 400 feet, with a general depth of 1 foot, and having usually a narrow and rapid channel of from 2 to 3 feet in depth. The bottom of the shoals in all cases I find to be a mixture of cobble-stones and coarse gravel and in the instances mentioned above a riprap of cobble stones and broken sandstone.

The flow of water to first division (between Elkhart and Berrien Springs) is usually quite strong and uniform, excepting at ripples where it is very rapid and above dams

where the current is slow but noticeable and decided. No special measurements were taken to determine the discharge of the stream. It, however, is quite ample for all purposes of canal navigation and water power. I have roughly estimated the discharge at Elkhart in time of low-water to be 1,200 cubic feet per second. The fall of the river from Elkhart to within a few miles of its mouth is quite uniform with the above exceptions of ripples and dams and is at the rate of 1.68 feet per mile. The rise of the river in time of freshet is from 4 to 6 feet. This usually occurs after the June rains. The river is very sensitive to rain storms, the water at such times rising very rapidly and going down as quickly. The course of the river is through a valley of from 500 to 2,000 feet in width, the banks or limits of which are from 25 to 60 feet in height. The banks of the river on one side from 25 to 60 feet in height and on the other from 4 to 10, and alternate from side to side, high and low, in accordance with the position of the stream in the valley, are composed principally of coarse gravel and sand, or clay, and at points between Buchanan and Berrien Springs a riprap of broken stone on one side with a stiff clay on the other. The country along the river is well adapted to agricultural pursuits, and throughout the entire length of stream is bordered with farms under a high state of cultivation. At Elkhart, Mishawaka, South Bend, and Niles, I find the river obstructed by dams, the dams, however, affording an excellent and never failing water power, and rendering the above localities noted for their manufacturing capacity and interests. At these dams I find no provision made in the shape of locks to pass vessels desirous of navigating the river. Should it be found expedient to improve the river for navigation the locations of the dams are such that locks can readily be built in connection with them, without materially impairing the usefulness of the dams as sources of power for manufacturing purposes.

The following from Turner's Gazetteer of the Saint Joseph Valley may be of interest in this connection:

"The Saint Joseph takes its rise in a small lake called Baw Beese, in Hillsdale County, Michigan, near the county seat, and runs thence northwest into Calhoun County. Near Tekonsha it makes an abrupt bend, and its general course thence to South Bend is southwesterly. From South Bend to Lake Michigan it runs nearly north. From its head to its mouth the river flows through a rich, level, and well-cultivated country, and neither upon or near any of its numerous tributaries can be found a mountain, nor many elevations that aspire to the dignity of hills. The face of the valley is undulating, sometimes quite rolling, but everywhere well adapted to purposes of husbandry. The landscape is beautified by many small lakes and brooklets, and occasionally unimportant marshes are found; but these last are fast disappearing under a uniform and general system of drainage.

"The source of the river is on the ridge dividing the waters of Lake Erie from those of Lake Michigan, and which is, perhaps, the highest point of land on the peninsula. The descent from Hillsdale to Lake Michigan is gradual, but constant and considerable, so that the Saint Joseph, although flowing through a remarkably level country, has at almost every point a rapid current. Being fed largely from springs and lakes, it is not subject to rapid and excessive rises, nor to inconveniently low stages of water. Inundations are infrequent and unimportant. Its chief tributaries are the Coldwater, Fawn, Pigeon, Little Elkhart, Elkhart, Dowagiac, and Paw Paw rivers, all of which are valuable mill streams.

"Unlike all mountain streams, the Saint Joseph, instead of decreasing in its volume as the surrounding country is cleared and improved, has exhibited a very decided increase. This is caused by the drainage of marshes and low lands, thus bringing into the current of the river a large quantity of water which was heretofore spread over a vast area and there been left to evaporate, to the detriment of health, and to the general damage and discomfort of the country.

"This accretion is constantly going on, and for many years must add very materially to the volume of the stream. A steamboat called the Schuyler Colfax, of about 200 tons burthen, is now, 1866, plying regularly between South Bend and the mouth of the river, meeting with little or no obstruction, even at the present low stage of water.

For years much of the commerce of this valley was carried on by steam and keel boats quite successfully. It now only requires a comparatively small outlay of means to complete slackwater navigation as far up as Three Rivers, in Michigan.

'A few locks and dams only are needed to perfect the navigation for steamers of 300 tons burthen. Such an improvement would be highly advantageous to those whose business involves the moving of heavy and bulky freight."

Upon the portions of the river examined I find thirteen bridges, two of which are railroad bridges, and the remainder used for highway purposes. Their elevation above low-water is shown on my profile of river. Under any system of improvement four of them, one a railroad bridge, must either be removed or raised to a greater or less extent, to permit the passage of steamboats.

The Saint Joseph River, to a certain extent, is navigable. For many years, steamboats and other craft daily plied between the towns and villages. The commercial importance of the stream, however, has rapidly decreased since the construction of

railroads, which now run along its banks and tap all the important shipping points. The inhabitants along its banks, who are interested, have seemingly deemed its value as a navigable stream of so little importance as compared with its value as a source of hydraulic power, that they have submitted to the construction of numerous dams in which no provision has been made by locks for the passage of vessels.

The navigation of the river at present is confined to that portion of the river between Saint Joseph and Berrien Springs, a distance by land of 15 miles, and by river of 25; also trips to Buchanan and Niles, when the depth of water is such as to permit the passage of boats to those points. At present, there are only two boats on this portion of the river doing a regular business. The smaller of these boats, the Republic, is engaged in the wood trade. She is a small stern-wheel canal-boat, of about 75 tons burthen, and draws when loaded about 2 feet of water. The other, the May Graham, a side-wheel steamer of 96 tons burthen, makes regular trips from Saint Joseph to Berrien Springs; she draws when loaded from 20 to 30 inches of water, and seems to be of ample capacity to do the business of the river at present. During the low stages of water she meets with many obstructions, and at times is obliged to discontinue the navigation over a portion of this route. The following estimate of the business done on the river between Saint Joseph and Berrien Springs, in the year 1878, was furnished me by Mr. James Brooks, master and owner of the steamboat May Graham. It is probably as fair and correct an estimate as can be had, from the nature of the business.

Freight down stream to Saint Joseph:

3,000 cords 4-foot wood.
500 cords stave bolts.
300 to 500 cords bass-wood.
300,000 feet hard wood.
3,000 to 5,000 railroad ties.
35,000 crates and baskets of fruit.

Also a large amount of apples and grain, not estimated.

It is impossible to estimate the freight up stream, for Berrien Springs and other landings. It consists of general supplies of all kinds, lime, salt, farming implements, and about 300,000 feet of pine lumber for building purposes.

The tonnage of the river during the year 1878 is as follows:

The steamboat May Graham, of 96 tons burthen, employs six men, and makes about 160 round trips during the season of navigation.

The *Republic*, of 75 tons burthen, employs the same number of men, and makes about the same number of trips. Her trips are mostly on the lower 14 miles of the river.

My instructions required of me an examination of the stream, for the purpose of determining if it is capable of being made navigable, and the cost of such improvements as are deemed necessary to make free navigation. Assuming, therefore, for the present, that the navigation of the stream is expedient and desirable, I will proceed at once to the consideration of such improvements as in my judgment seem to be necessary to accomplish the desired results.

In this report I offer no solution to the many problems which are presented, giving only general results. The first question that presents itself is as to the depth of water required. In my letter of instructions no suggestions were given me on this question, for upon the existing facts as found by my examination, the necessary depth of water should depend. In other words, upon the amount of business to be carried on will depend the depth of water to be prepared, and we find on the other hand in this instance that upon the amount of water made available probably will depend the amount of business. From an examination of my maps it may be seen that in the worst stage of water a depth of no less than 16 inches may be relied upon. If with this depth of water navigation should practically cease on a greater portion of the stream, and entirely cease on that portion accessible to railroads, it is evident that to revive the river business, a depth of water far exceeding this must be prepared and maintained.

The navigation of the river between the limits of survey might be considerably improved for such boats as are now used on the last 20 miles, by cutting sluices through the shoals from 30 to 50 feet wide, and from 2 to 3 feet in depth. This, with a judicious use of wing walls or dams to contract the width of the stream at places, would probably give a depth of water of from 2 to 3 feet. I, however, consider this method very unreliable, and in the present case not desirable except on that portion of the stream between Saint Joseph and Berrien Springs, where a slight improvement would give ample depth for all present purposes. The cost of improving this portion of the river by the foregoing method I have estimated at $11,300. The extent to which this method would improve that portion of the river above Berrien Springs is very uncertain. The fall of river for the depth of water is very great, and by the contraction of the channel or the removal of bars at one point, it is highly probable that obstructions fully as great would be developed at other points. I find

on the river several places where this method has been tried, and in every instance the river at these points is in a very bad condition. Also the location of the river, except that portion between Berrien Springs and Saint Joseph, is such in regard to railroads, that in order to insure a business of any importance on the river, its navigation must be made uniform and reliable and not depending upon or subject to the accidents of flood or freshet. My estimates by the foregoing method are as follows:

From Saint Joseph to Berrien Springs.

Wing-dams, 2,200 linear feet, at $3	$6,600 00
Excavation, 14,000 cubic yards, at 30 cents	4,200 00
Drift-wood, snags, &c., removing	500 00
Total	11,300 00

Berrien Springs to Buchanan.

Wing-dams, 1,650 linear feet, at $3	$4,950 00
Excavation, 20,000 cubic yards, at 30 cents	6,000 00
Removing or elevating bridge	1,000 00
Total	11,950 00

Buchanan to Niles.

Wing-dams, 1,000 linear feet, at $3	$3,000 00
Excavation, 1,296 cubic yards, at 30 cents	388 80
Total	3,388 80

Niles to South Bend.

Locks, 1, 35 feet wide by 140 feet long	$15,000 00
Wing-dams, 400 linear feet, at $3	1,200 00
Excavation, 3,703 cubic yards, at 30 cents	1,110 90
Raising or removing one bridge	500 00
Total	17,810 90

South Bend to Mishawaka.

Locks, 1 at South Bend	$15,000 00
Raising bridges	2,000 00
Excavation, 300 cubic yards, at 30 cents	90 00
Stone and drift-wood, removing	200 00
Total	17,290 00

Mishawaka to Elkhart.

Locks, 1 at Mishawaka	$15,000 00
Wing-dams, 1,600 feet, at $3	48,000 00
Excavation, 10,000 cubic yards, at 30 cents	3,000 00
Elevating and removing bridges	500 00
Total	23,300 00

Making, in all, $85,039.70, to which should be added engineering expenses of 10 per cent., making the estimated cost by this method $93,543.67.

I consider that in any improvement of this kind, where the commerce by river may be said to be prospective and depending upon such improvement, that the system adopted should be one that will be permanent, and the depth of water proposed should at least coincide with the usual river navigation, and boats for its navigation should be prepared for that special purpose.

In my estimation, slackwater navigation presents the only solution to this problem.

The following estimates of the cost of making a depth of 4 feet by means of locks and dams is presented. It is only approximate, and will be of value only so far as it shows the probable cost of such an undertaking. In order to make estimates of any value, special surveys must be made at the locations of the several locks and dams as determined by my profile of the river. In this estimate no account is had of the land necessary to be purchased for the work, nor for damages caused by the flooding of land or otherwise:

ESTIMATES OF COST OF IMPROVING THE RIVER BY MEANS OF LOCKS AND DAMS.

Dams, 8, not counting those already built, at $30,000	$240,000
Raising South Bend Dam 3 feet	3,000
Raising Mishawaka Dam 3 feet	3,000
Raising bridges	4,000
Locks, 11, at $20,000 each	220,000
Excavating 355,542 cubic yards earth, at 30 cents	106,665
Contingencies and engineering	57,666
Making a total of	634,331

The works when completed would probably not be self-sustaining, and would require large appropriations each year for lock-keepers and other expenses.

I found a great diversity of opinion among the residents along the river as to the necessity or advisability of improving the river for navigation. From Niles to Elkhart the country is so thoroughly cut up and supplied with railroads that it cannot be considered a necessity; while, on the other hand, competition in freight of all kinds to be moved to and from the above localities would make the improvement seem desirable. From Niles to Saint Joseph we find a large tract of country depending, in a measure, upon the river as a highway for its grain, fruits, and timber to market, and farming implements and supplies of all kinds in return. An appropriation of even $10,000, expended on that portion of river between Berrien Springs and Saint Joseph, would be of great benefit to that section. Taken as a whole, I find the section of country through which the Saint Joseph River runs to have no widely-extended wants to be supplied. The river is not, and the proposed improvement would not make it, a trunk-line for freight or commerce. The improvement would depend mostly on local traffic to sustain it, and I am of the opinion that it would become entirely inoperative for the want of such traffic.

SAINT JOSEPH AND BENTON HARBOR SHIP-CANAL.

The survey of the channel leading from Saint Joseph to Benton Harbor, a distance of 4,800 feet, is made a part of this report.

The survey, location of canal, and plat of sounding are fully shown on the accompanying maps. The work of constructing this canal or slip was commenced about the year 1860 as a private enterprise. The work was only partially completed at that time, and until 1870 was in a very useless and unfinished state. In that year the work received aid to the extent of $15,000 from the town of Benton. With this appropriation the work was placed in its present condition, with the exception of a wing-dam at its junction with the Saint Joseph River.

In the year 1875, under an appropriation from the general government, the sum of $9,046.24 was expended in building a wing-dam in the Saint Joseph River at the mouth of the canal. This work was built for the purpose of improving the harbor at Saint Joseph as well as to deepen the water at the mouth of the canal. In the year 1879 the legislature of the State of Michigan passed an act making the waters of this canal a public highway forever for the citizens of the United States and subject to the laws governing public navigable waters.

The canal has always been free to navigation.

At the commencement of the work a cheap pile revetment was built and now exists as a protection to the south bank of the canal. It is now fast going to decay. No works of any kind exist for the protection of the north bank of the canal, which, from the nature of its soil, is constantly being washed away and into the canal. The canal at present is about 100 feet in width, and will permit the passage of vessels drawing 8 feet of water.

To successfully carry on the commerce at Benton Harbor a depth of at least 12 feet is required.

To complete the canal to this depth would require the excavation of 56,889 cubic yards, at 15 cents per yard	$2,844 45
Contingencies	400 00
Making a total of	3,244 45

The tonnage at Benton Harbor for the year 1878 is as follows:

	Tons.	Men.
Propellers	90,776	4,402
Vessels	3,355	294
Total	94,131	4,696

The tonnage at Saint Joseph for same year was:

Arrived:

Number	287
Tons	101,534
Men	4,714

Cleared:

Number	285
Tons	100,844
Men	4,710

This does not take into account vessels arriving at these ports from other ports in the same collection district. This trade is a very large one, and would greatly increase the numbers above given.

Very respectfully, your obedient servant,

JOHN A. MITCHELL,
Assistant Engineer.

Maj. F. HARWOOD,
Corps of Engineers, U. S. A.

G G 21.

SURVEY FOR A BREAKWATER AT MACKINAC, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 19, 1880.

GENERAL: In accordance with your instructions of April 25, 1879, I have the honor to submit my report of a survey for a breakwater at Mackinac, Mich., provided for by act of Congress approved March 3, 1879.

By correspondence with interested persons I first ascertained that this survey was asked for, having in view the protection of the anchorage and wharves in front of the town of Mackinac, on the island of the same name. It was claimed that the interests of commerce at this point were impaired from two sources—first, the denudation of Biddle and Mission Points by the waves and stormy weather, thereby encroaching upon the anchorage with deposits of sand and gravel washed from these points; secondly, as a result of the denudation of these points, an increasing exposure of the existing wharves in stormy weather, making it difficult, and sometimes impossible, for vessels to make their landings until the storm had subsided. Upon examination, I found that the first evil complained of was an accomplished fact, both points having been completely stripped of all sand and gravel exposed to the wash of the waves, and as a result the shoals indicated on the map herewith submitted have formed. These shoals, when properly buoyed, are, however, no material obstacle to navigation, there being sufficient depth of water over the heads of them to float vessels of the heaviest draught known on the great lakes, with ample channel-way also between Mackinac and Round Islands, and it is probable that the slight annual increment to these shoals might go on for many years without interfering with navigation more than at present, until finally the shore-line would wash down to an easy curve and the shoaling cease, still leaving sufficient water for vessels of ordinary draught to approach the village wharves. Such a result, however, would prove of serious detriment to the interests of navigation on another account, and that the increase of the evil already existing, viz, the exposure of the landing to the waves in stormy weather, resulting from the gradual washing away of both points. Local history has it that where there are several feet of water

off Biddle Point, as it now exists, not many years ago trees stood, and a fine level plateau existed, upon which the garrison of Fort Mackinac was accustomed to parade in fine weather.

By reference to the extract from the Lake Survey Chart, which appears upon the map herewith forwarded, it will be seen that the waves from Lake Michigan rushing in from the westward, and which were formerly shut out by Biddle Point acting as a breakwater, now have a clear sweep, rolling around the point to the Mackinac wharves; and the same can be said of waves from the eastward, which have a long course clear across the head of Lake Huron, and, Mission Point forming no material obstacle, drive with great fury directly upon the Mackinac beach at the town front. Under such circumstances, vessels will not attempt to land, neither, when the gale is very severe, do they even dare to let go anchor, but, passing the harbor by, seek shelter under the lee of the islands elsewhere. As, during the season of navigation, Mackinac is a regular port of resort for passenger steamers plying between Lakes Michigan and Superior, and is visited by large numbers of tourists and pleasure seekers, the want of a snug harbor is a great inconvenience to the passenger traffic, as well as a detriment to the interests of the numerous passenger lines which touch at the island, as they never are certain when they can land their passengers without the material delay prejudicial to their freight interests at either terminus of their route. It is, therefore, decidedly to the interest of this branch of commerce that a harbor should be formed at this point, which shall be readily accessible in all weathers, and secure for landing at the wharves within its limits, no matter how heavy a gale of wind may be blowing outside. To secure such a snug harbor, the obvious method would be to run out converging piers from Biddle and Mission Points, leaving between their respective heads just sufficient channel way for vessels to pass commodiously in all weathers. Such a project is, however, defeated by the peculiar hydrography off Mission Point, a deep hole existing there in the middle of which 60 feet soundings were found and no bottom. This hole, which is probably the remnant of what was the ruling depth of the harbor before Biddle and Mission Points were denuded, forms an effective barrier to the extension of a pier from Mission Point beyond the crest of its bank, and similarly a converging pier from Biddle Point would be headed off at a distance of about 1,000 feet from the Mission Point pier-head, and hence be no more effective in securing a snug harbor than a shorter pier run at nearly right angles to the direction of the greatest waves. It is obvious that in each case a pier so run will cover the greatest area of anchorage in proportion to its length. I have so projected a pier at Biddle Point on the map accompanying this report.

The direction and length of a pier at Mission Point are determined by the peculiar conformation of the bottom, as shown on the chart. Fortunately, excepting as to length, it is all that can be desired, while without going into too deep water the Biddle Point pier as projected will cover all the area between it and the Mission Point pier from direct exposure to the waves attacking from the direction of Biddle Point. I therefore propose, as the improvement proper to be made at Mackinac Island for the protection of its harbor, two piers putting out severally from Biddle and Mission Points, the direction of each to be nearly at right angles to the direction of attack of prevailing heaviest waves, and each to terminate in a pier-head 40 feet square, standing in 24 feet soundings, which is the sounding at the crest of the hole off Mission Point. As with the limited time and appliances at my disposal it was necessary to take soundings by time intervals as determined by the

watch, owing to irregularity in stroke of oar the position of curves of soundings must be necessarily approximate, and, consequently, the lengths of the proposed piers as projected on the map are also approximate. It is safe to say, however, that the Biddle Point pier should be from 1,200 to 1,500 feet long, and the Mission Point pier from 800 to 1,000 feet, the location of its head being positively determined by the crest of the declivity ahead of it.

Owing to the character of the foundation, the gradual slope of the bank, and the peculiar impact to which the piers will be subjected from the short, high, and rapidly propelled waves attacking them and delivering a series of blows rather than thrusts, the ordinary method of pier construction will not be advisable at this locality. The bottom being of loose stone, gravel, and bowlders, the slope gradual, and the waves violent and percussive, in my opinion a vertical face should not be opposed to their impact, but they should be received upon the slope of a pier having a base broad in proportion to its height, thus obtaining a good hold on the unstable foundation while breaking the force of the shock of the wave at the water-line. The Biddle Point pier will need to have both faces a slope above water, as otherwise, when the waves come from the eastward, rolling past the Mission Point pier, should they meet a vertical face at the Biddle Point pier, a troublesome reflex wave would be thrown back upon the Mackinac wharves. The Mission Point pier might have the inner face vertical, but as there would be little economy in it I should propose for both piers a rectangular cross-section up to the water-line, and a trapezoidal cross-section in superstructure. A uniform base of 30 feet width is, in my opinion, necessary to secure the pier from shifting its base while in process of construction, and to insure adequate weight of stone in the trapezoidal area. Piers of the shape and construction I propose would cost at these sites about $50 per linear foot, or, for the Biddle Point pier, from $60,000 to $75,000, and for the Mission Point pier from $40,000 to $50,000.

By aid of an appropriation of $125,000 both works could be completed in one season.

Mackinac Harbor is located in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich. It is about equidistant from Cheboygan and Saint Helena light-houses, and Fort Mackinac is on the hill above the harbor.

The amount of revenue collected at Grand Haven has no relation whatever to this improvement, but further commercial statistics are contained in the letter of Mr. James Danhof, deputy collector of customs, Grand Haven, Mich., hereto appended.

* * * * * * *

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

COMMERCIAL STATISTICS.

1.

CUSTOM-HOUSE, GRAND HAVEN, MICH.,
Collector's Office, January 9, 1880.

DEAR SIR: In reply to yours of the 30th ultimo, I respectfully inform you that your letter has been referred to Mr. James Lasley, deputy collector of customs at Mackinac, Mich., for the reason that we have not the data necessary to give the information you required.

The condition of ice in the Straits is such that correspondence is materially impaired and we get no answer. As soon as we do get an answer we will forward it to you.

The collections at Mackinac during the past year were $453.35.

It appears by the records of this office that the total number of arrivals and clearances, with the aggregate tonnage, during the past season, is as follows:

Arrivals:	
Number	128
Tonnage	62,379
Clearances:	
Number	128
Tonnage	62,379

This is too small, as a large number of vessels go in and out at Mackinac but do not report or clear, and consequently do not appear on our records, as was stated by Mr. Stephenson in his letter to you several days ago.

Very respectfully,

JAS. J. DANHOF,
Deputy Collector of Customs.

Maj. F. HARWOOD,
Corps of Engineers, U. S. A.

2.

CUSTOM-HOUSE, GRAND RAPIDS, MICH.,
Collector's Office, January 26, 1880.

SIR: In reply to your letter of December 24, I have the honor to submit a letter and statement from James Lasley, deputy collector at Mackinac, stating the necessities for protection to the anchorage at Mackinac.

I observe that he did not give the tonnage of each steamer constituting the several lines, as requested. They are as follows:

	Tonnage.
City of Duluth	1,110.18
City of Fremont	705.75
J. L. Hurd	759.88
Peerless	1,199.50
Nyack	1,257.35
Saint Louis	965.27
Badger State	1,115.52
Idaho	1,110.97
Oneida	1,070.50
Fountain City	969.58
Canisteo	856.07
Toledo	792.25
City of New York	416.71
City of Concord	440.93
Oswegatchie	436.55
Champlain	437.92
Nashua	440.59
Garden City	436.76
Milwaukee	419.11
City of Toledo	413.27
A. C. Van Raath	176.63
City of Grand Rapids	335.30
Philadelphia	1,463 60
Egypt	1,429.78

I do not find the *Blanchard* on our list, and am unable to give her tonnage.

Respectfully,

J. A. STEPHENSON,
Deputy Collector.

Maj. F. HARWOOD,
Corps of Engineers, U. S. A.

3.

CUSTOM-HOUSE, MACKINAC, MICH.,
Collector's Office, January 10, 1880.

SIR: Concerning the amount of commerce that would be benefited by breakwaters at this harbor, I would respectfully observe that it would certainly be a great benefit to all the tonnage from Buffalo to Chicago and Chicago and Lake Superior for shelter, business for coaling, this being a coaling station. The trade of the Island is considerable, and the nearest estimate I was capable to gather in reference to the trade of the Island, viz: Imports, say $200,000; exports, about $90,000. All supplies for the military post are received at this port; for a portion of the season of navigation this is the terminus of the Grand Rapids and Indiana Railroad, the connection being made by daily boat to Petoskey. The passenger-list of steamers arriving here during each season is very large, including people from nearly every State, who visit the Island for health and recreation. The Island has for years been a favorite resort for invalids and tourists, and is rapidly gaining in popularity.

Concerning the necessity of protecting the harbor, I would observe that the first and great benefit would be the protection of our lake marine, nearly all the large passenger steamers on the lakes calling here regularly, besides many transient ones and numerous tugs, sailing craft, &c. Many more would come in for shelter if there was proper protection. The second principal benefit would be the protection of public and private property bordering upon the harbor, public wharves, streets, &c., which are much exposed by action of the waters; a breakwater on either point of the harbor would also be of great benefit to the government in protecting the water-front of Fort Mackinac, which comprises nearly one-third of the water-front of the harbor. An appropriation can be asked for several reasons: the first would be for reasons already set forth; the second would be that the port arrivals and clearances of large steamers are larger than many ports in Michigan. This being, with one exception, the oldest port of entry on Lakes Michigan, Huron, or Superior, and never having asked or received a dollar from the government for harbor improvements or protection, it would seem that the appropriation for protection of this harbor now asked for should be made, and that the work would be of much benefit to all concerned.

Respectfully,

JAMES LASLEY,
Deputy Collector of Customs.

4.

CUSTOM-HOUSE, GRAND HAVEN, MICH.,
Collector's Office, January 10, 1880.

Annual report of the deputy collector of customs at Mackinac, in the district of Michigan, for the year 1879.

	Tonnage.
Entered and cleared from the Port of Mackinac	67,921
Way boats, Chicago and Lake Superior Line, viz: City of Duluth, City of Fremont, Peerless, J. L. Hurd	199,600
New York Central Line, viz: Nyack, Saint Louis, Badger State, Idaho, Oneida, Fountain City	301,784
Union Steamboat Line, viz: Canesteo, Toledo	67,104
Northern Transportation Line, viz: City of New York, City of Concord, Oswegatchie, Champlain, Nashua, Garden City, Milwaukee, City of Toledo	70,400
Petoskey Line, viz: A. C. Van Raath, City of Grand Rapids	17,035
Transit, New York Central, viz: Philadelphia, Egypt, Blanchard	3,400
Total tonnage	727,244

G G 22.

RESURVEY OF BAR AT MOUTH OF BELL RIVER, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., May 8, 1880.

GENERAL: The following report upon the examination of the bar at the mouth of Bell River, Michigan, has been delayed by the open winter

which has interfered with surveying on the ice, and by the difficulties I have met with in obtaining any reliable information as to the nature and extent of the improvement desired at this point, so that it was not until this spring that I have been in possession of the necessary data upon which to base a survey or examination.

Bell or Belle River (it is spelt variously) is a small stream of about 140 feet width from bank to bank, debouching into the Saint Clair River at Marine City. Marine City is the depot of an extensive tract of fine oak timber suitable for ship-building and vessel repairs, and hence ever since there has been any commerce on the Great Lakes has been a favorite place for laying up vessels for the winter, as they could there be berthed and receive necessary repairs at a cheaper rate than at their several ports of hail. For a mile from its mouth the northeasterly bank of Bell River is the seat of several ship yards for building and repair, and has been used also for a berthing ground during the winter for such vessels as were able to enter. Of late years, however, the silt deposit from the headwaters has so shoaled this lower reach, and more particularly at the mouth, where the embouchure is of a shape unfavorable to scour, that only very light-draught vessels have been able to enter, and the heavier-draught ones have been obliged to tie up along the Saint Clair front or else seek berths at other ports. These vessels, which on account of their larger size and tonnage are the most valuable of the vessel property wintering at Marine City, are in annual danger of damage or possible total loss when the ice breaks up in the Saint Clair River in the spring, and in fact the moral of this report was very near being pointed in a most emphatic manner by the break-up of this spring, which carried away all of the vessels on the Saint Clair front near the mouth of Bell River, parting their moorings, pulling, and breaking piles, racking and damaging the dock to which they were made fast, and threatening for the time the total destruction of the entire fleet. Fortunately a fetching up of the floe enabled the property to be secured. The improvement then which is desired at the mouth of Bell River is the opening of a channel of sufficient depth and width and length to berth during the winter all the vessels which habitually seek winter-quarters at Marine City. Appended and marked "A" is herewith respectfully submitted a list giving the names, tonnage, owners, port of hail, and insurance valuation of the vessels which laid up at Marine City during the winter of 1879–'80. From this list it will be seen that nearly $500,000 of vessel property was berthed at this place, of which about two-thirds was in danger of running ice and in fact made narrow escape from severe damage or total wreck. From the construction of lake propellers and steam barges having their machinery at the stern, they draw unloaded nearly as much as they do when loaded, and to enable them to berth in Bell River a depth of 13 feet water must be attained for those of the larger tonnage. To accommodate all that seek these winter quarters, the entire stretch of river, 5,330 feet in length, from the mouth of the upper village bridge, should be dredged to 12 or 13 feet depth with a minimum width of 50 feet, the least that will enable them to seek and leave their berths without blocking the channel. I therefore estimate for the construction of a harbor of refuge from ice at the mouth of Bell River, Michigan, as follows:

To dredge a channel 13 feet deep and 50 feet wide from the mouth of the river to the lower Marine City drawbridge, 2,580 feet length of channel, 26,000 cubic yards silt and clay dredging, at 25 cents per cubic yard, $6,500.

To dredge a channel of same width and 12 feet depth, 2,750 feet in length, between the two bridges, 25,000 cubic yards dredging same character, at 25 cents per cubic yard, $6,250.

To secure the channel thus dredged from shoaling at the mouth, the banks must be rectified and confined within limits corresponding to the width of water-way ruling above. The present shoaling is in no wise due to the cross current of the Saint Clair River, for there is ample depth of water at the mouth of Bell River in the Saint Clair to receive all the silt Bell River may send down for years to come and show no perceptible shoaling, as the swift current will carry away nearly all the silt in suspension before it has time to deposit. The shoal at the mouth is, in my opinion, due solely to defective dock lines and lack of proper confinement of the water-way, all of which can now be readily remedied and the lines defined before the ground is taken up for shipping purposes. To do this there will be required—

1st. A pile and edging revetment, 800 feet in length, at $3.25 per linear foot, $2,600.
2d. Removing 316 cords of old slab bulkhead, which protrudes beyond proposed channel limit, at $1 per cord, $316.
Pulling 40 piles in same, at $2 per pile, $80.

I regret that the necessity of making speedy report on this and another survey precludes the possibility of my sending an accompanying sketch, showing the boundary lines I propose for the mouth of Bell River, but it will be forwarded as soon as I am able to prepare it.

RECAPITULATION.

SUMMARY OF ESTIMATE.

51,000 cubic yards dredging, at 25 cents	$12,750
800 linear feet revetment, at $3.25	2,600
Wrecking end of old slab bulkhead	400
	15,750
Engineering contingencies, 10 per cent	1,575
	17,325

Estimate, $17,500,

The mouth of Bell River is in the collection district of Huron, Mich., the nearest port of entry being Port Huron, the nearest light-house at Fort Gratiot. During the fiscal year ending June 30, 1879, there were 306 arrivals of vessels with aggregate tonnage, 27,925, and 276 clearances, aggregate tonnage, 25,452, and about $1,200 revenue collected; but the amount of commerce to be benefited by the improvement can be best arrived at by considering the list of vessels berthed at Marine City during the winter of 1879–'80 and hailing from various ports.

The construction of a harbor of refuge from ice at the mouth of Bell River would be of general benefit to the commerce of the Great Lakes.

All of which is respectfully submitted. And

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

A.—*Vessels laid up at Marine City, Mich., February, 1880.*

Names.	Tonnage.	Owners.	Port of hail.	Insurance valuation.	Remarks.
Charles Spademan	306	Rice and others	Marine City	$7,000	
H. D. Coffinbury	650	Rust, King & Co	Cleveland	35,000	
Salina	212	R. Holland	Marine City	6,000	
S. Gardener	238	do	do	2,500	
Cleveland	461	Thos. Lester and others	do	7,500	
Chicago Board of Trade.	423	H. Howgood	Milwaukee	7,000	
Germania	263	H. Butteroni	Marine City	18,000	
Wm. Cowie	209	Leith and others	do	9,000	
Bay City	372	Rust and others	do	16,000	
D. F. Rose	358	Parker and others	do	12,000	The first twenty-one vessels on the list were moored at the docks in St. Clair River and exposed to the ice.
Geo. King	533	Francis and others	do	30,000	
V. H. Ketchum	1,660	Adams and others	Cleveland	60,000	
Tempest	415	T. and S. T. Co	Toledo	17,000	
C. G. King	525	Rust, King & Co	Cleveland	12,000	
Newcomb, H. B	613	Rust & Co	do	26,000	
D. W. Powers	302	Morley Bros	Rochester	16,000	
C. H. Birkhead	569	T. and S. T. Co	Toledo	16,000	
N. K. Fairbank	970	Morley Bros	Rochester, N. Y	46,500	
Mary Mills	119	M. C. S. Co	Marine City	4,000	
J. L. Ketchum	425	Osburn & Dutton	East Saginaw	4,000	
Abercem	270	Leitch and others	Marine City	18,000	
Rosebel	504	Allen and others	Algonoc	8,000	All below this line were moored in Bell River, and in no danger of an ice drift. Most of the first named were steamers and could not enter Bell River.
Marine City	337	Parker and others	Marine City	3,000	
Wm. Bissel	278	Butt and others	Cleveland	3,500	
New Baltimbre	80	J. Lozen	New Baltimore	7,500	
Buckeye State	519	J. F. Rust & Co	Cleveland	9,000	
Mary Berkhead	165	Thos. Lester and others	Marine City	2,500	
Matilda	309		do	1,800	
Troy	486	T. & S. T. Co	Toledo	10,000	
Dayton	461	do	do	9,500	
Agnes	80	John Wansey	Marine City	2,000	
N. P. Goodell	224		Forester	3,000	
Shiawassee	153	Hanford and others	St. Clair	2,000	
Reindeer	160	Mitchell	Toledo	2,000	Of those in Bell River only one was a steamer, and she is small and light draught.
Tailor	298	H. Butteroni	Marine City	7,000	
John F. Warner	200	Walker & Lester	do	2,500	
C. L. Young	382	Francis	do	6,000	
St. Joseph	165	M. Licken	do	2,000	
Dolphin	200			1,000	
Gibhart	354	T. and S. T. Co	Toledo	8,000	
Katie Brainard	412	do	do	8,500	
Hoag	300	Pool and others	Marine City	3,000	
D. H. Keys	250	Pringle and others	do	2,000	
Grond total	16,110			479,500	

G G 23.

RESURVEY OF CLINTON RIVER, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., May 22, 1880.

GENERAL: I have the honor to transmit herewith a copy of the report of Mr. B. H. Muehle, assistant engineer, of his survey of Clinton River, Michigan, which he has just completed under my instructions, in fulfillment of the provisions of act of Congress approved March 3, 1879, which has been delayed for the same reasons noted in my report upon the resurvey of bar at mouth of Bell River. Mr. Muehle's report, while giving the full facts in the case, so completely expresses the views I had already formed from a cursory reconnaissance of the reaches of river in question, that I have but little to add in remark and that only in way of explanation.

I am somewhat disappointed at the result of the examination of the mouth of the river, where local indications pointed to possible channels,

cutting off shoal reaches and avoiding the cross drift of the littoral current, which has in process of time almost obliterated the embouchure of several years ago. The result of Mr. Muehle's investigation shows, however, that this channel of exit must be restored and protected by a pile and edging revetment before any other improvement of the upper reaches of the river can be of material service to navigation. All of the items of improvement estimated for by Mr. Muehle are, in my opinion, necessary to the complete restoration of navigation with 8 feet soundings from Lake Saint Clair to Mount Clemens, which is practically the head of navigation. The commerce of the river, which is purely local, has waned considerably in past years, owing to the deterioration of the navigable channel. The village of Mount Clemens has, however, steadily increased in prosperity notwithstanding, and principally on account of the celebrated mineral well there situated, which has a national reputation for effecting marvelous cures of rheumatism, neuralgia, and like diseases. This well and the baths attached attract each year a large concourse of visitors and patients, which has, of course, enhanced the prosperity of the village and led to the building of large hotels, one of which, now under contract, requires over 1,000,000 feet, board measure, of lumber in construction, all of which has to be lightered at the mouth of the river, but which, if the river navigation were improved, could be delivered on the bank at the hotel site without breaking bulk. And so in the case of any other shipment.

The restoration of the channel of 8 feet depth would therefore greatly stimulate the local commerce and revive drooping industries, the characters of which are fully set forth in the accompanying papers of statistics furnished me by the honorable Edgar Weeks, member of legislature.

I also append two sketches illustrative of the improvements proposed at the upper reaches of the river, that at the mouth being a simple renewal of the old channel already recorded and not requiring illustration. Mr. Muehle's estimates of expense of improvement are far too low, owing to the late advance in cost of labor and material. This advance would warrant an increase of his estimate to at least $25,000, which could be profitably expended in one year, completing the improvement, or if this could not be afforded, an appropriation of $10,000 would effect the improvement of the river's mouth, giving easy access to still water, but would still leave the up-stream improvements to be taken in hand, without which all cargoes to and from Mount Clemens would still have to be lightered.

The Clinton River is situated in the collection district of Detroit, which is the nearest port of entry, and whose commercial statistics have, however, no bearing on the commerce of Clinton River, which is purely local, and fully described in the papers herewith forwarded. The benefits to commerce to result from the improvement would therefore be purely local. The nearest fort is Fort Wayne, Mich., and the nearest light-house Saint Clair Flats beacons.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. B. H. MUEHLE, ASSISTANT ENGINEER.

MOUNT CLEMENS, MICH., *May* 17, 1880.

MAJOR: I have the honor to report that I have completed the examination of Clinton River, Michigan. Soundings taken on numerous diagonal lines crossing the axis

of the river throughout its entire length from the mouth to the bridge at Mount Clemens, established the fact that there are but three principal obstructions to navigation, viz, a shoal opposite the saw-mill at the easterly outskirts of Mount Clemens, the curves in the river in the vicinity of Shoemaker's farm, including the "island" (a shoal), and the channel entrance at the mouth of the river. Excepting these obstructions, there is found in the channel of the river a depth of no less than 8 feet of water, with a width varying from 30 to 80 feet; in the narrower reaches of the river, soundings over 15 feet of water were of frequent occurrence.

1st. The shoal opposite the saw-mill (B. Landeyhem & Sons) is located near the middle of the channel, the north shore of which is used for a boom by the mill-owners. There is a break in the high bank of the south shore, through which in times of freshet, the water forces an outlet to a swampy and low land beyond by which action the speed of the current is retarded in a manner to make and increase the deposit on the shoal. This break should be closed by a revetment of piles and plank, with a backing of brush or stave-mill refuse, a length of 200 feet, estimated at $200 per linear foot. A channel 50 feet wide may then be dredged, connecting the deep water above this shoal with the 8-foot curve below by an excavation of 3,600 cubic yards. A sketch of this shoal and proposed improvement is herewith respectfully submitted.

2d. In the vicinity of Shoemaker's farm upon the south shore of the river, about 1 mile below Mount Clemens, a complication of obstructions is found in two very sharp curves, and a tortuous channel around a shoal, which was formerly an island, immediately below. It appears feasible to straighten this reach of the river by cutting off either one of two points of land, there being bayous in rear of them, which seem to have been cut and formed by the current of the river during periodical freshets. On the accompanying sketch it will be seen that the point opposite the Shook farm cannot be separated from the mainland with such good result and benefit to navigation as might be supposed upon a cursory examination of the locality, inasmuch as the two sharp curves complained of would still remain though shortened. The good channel of deep water from B to D must be abandoned, and the shoal water between A and C will require dredging. An attempt to cut through the high bank in the direction from C to D, in order to make a nearly straight and direct connecting channel, would necessitate the cutting off of a considerable portion of the point of land opposite C, both excavations being excessively expensive. In view of the above, the cutting off of the other point of land opposite Shoemaker's farm appears to be a project more worthy of serious consideration in this connection. A bayou extends from Shook's Point (B) to within about 150 feet of the upper reach at Charbenau's, a total distance of 1,000 feet. The south shore at the upper reach has been gradually wearing away under the action of the current sweeping around the curve above, which shows that if a channel were opened at that point the current of the river would immediately enter and scour the bottom of the new river-bed in a manner to preserve its original depth, and prevent the formation of sand-bars.

A channel 75 feet wide may be made through this bayou by the excavation of 30,000 cubic yards of clay mixed with sand, one-half of which quantity may be thrown up on the south side of the canal to form a new river bank; the balance should be dumped in the deep water of the middle bend (C B), which will then become useless for navigation, and may be completely cut off by pile and plank revetments with brush backing. One of these will be required at the upper bend (A), 200 feet long, and one at the lower end (B), 300 feet long; total, 500 linear feet, at $2 per foot.

A straight connection being thus established between the deep water at Charbenan's Bend and Shook's Point, it will be necessary to remove the "island" immediately below by dredging about 4,000 cubic yards of sand and gravel, nearly all of which must be removed into deep water. If a revetment is deemed necessary along this new channel, it will have to extend from the east end of Shook's Point to the north shore, opposite Teat's farm, a distance of 500 feet, and in that case one-half of the excavated material at that point may be thrown over and deposited behind such revetment.

3d. The mouth of the river is obstructed in the vicinity of the old light-house by a shoaling of the channel, produced by the littoral current and the not quite expended force of the current of the north channel of the Saint Clair River, which enters Lake Saint Clair north of this point. The channel, dredged in an easterly direction into deep water under a government appropriation nearly ten years ago, has filled up to some extent, making it narrower, and, in consequence of vessels crowding, scraping, and plowing their way into harbor when accidentally off their original and proper course, more tortuous and winding. Deep water in this line is reached about half a mile from the mouth of the river, by far the shortest distance therefrom I have been able to find it in any other direction. A revetment protecting this channel upon the north side will have to be 2,500 feet in length, and should be so constructed of piles, plank, and brush backing that the material hereafter excavated for the purpose of deepening the channel may be thrown over and deposited behind the revetment to a

sufficient height above water level to permit the planting of willow cuttings, which may be readily obtained from the superabundant growth upon the banks of the Saint Clair Flats Canal.

Estimating the average depth of cut required to make 8 feet of water in this outer channel at 2 feet, an excavation of 10,000 cubic yards will afford immediate relief to the vessels entering and leaving the mouth of Clinton River.

In conclusion, I beg leave to submit a consolidated approximate estimate of cost of improving Clinton River.

Very respectfully, your obedient servant,

B. H. MUEHLE,
Assistant Engineer.

Maj. F. HARWOOD,
Corps of Engineers, U. S. A.

CONSOLIDATED APPROXIMATE ESTIMATE OF COST OF IMPROVING CLINTON RIVER, MICHIGAN.

1st. Shoal at Mount Clements:	
Dredging 3,600 cubic yards, at 15 cents	$540
Pile revetment, 200 linear feet, at $2	400
2d. *a.* Cut at Shoemaker's:	
Dredging 15,000 cubic yards, thrown over, at 10 cents	1,500
Dredging 15,000 cubic yards, dumped, at 15 cents	2,250
Pile revetments 500 feet long, at $2	1,000
b. "Island" below Shook's Point:	
Dredging 4,000 cubic yards, at 15 cents	600
Revetment (contingent) 500 feet, at $2	1,000
3d. Outer channel:	
Dredging 10,000 cubic yards, at 15 cents	1,500
Revetment 2,500 feet long (contingent)	5,000
Add 10 per cent	1,379
Total	15,169

Respectfully submitted.

B. H. MUEHLE,
Assistant Engineer.

MAY 17, 1880.

COMMERCIAL STATISTICS.

EXTRACT FROM LETTER OF COLLECTOR OF CUSTOMS, DETROIT, MICHIGAN, TO HONORABLE EDWARD WEEKS, MOUNT CLEMENS.

CUSTOM-HOUSE, DETROIT, MICH.,
Collector's Office, March 2, 1880.

SIR: I find that during the season of 1879 there has entered and cleared at the port of Mount Clemens 217 vessels, with a tonnage of 9,893 tons; value of imports, $4,999; and revenue collected, $187.15. The number of vessels entered and cleared do not include those vessels that may have entered from, or cleared to, other ports in the district, as the law does not require them to make such report, or take out a clearance. The steamer Ida makes daily trips from Detroit to Mount Clemens, and being in the same district is not required to report or clear.

* * * * * * *

I am, sir, very respectfully,

D. V. BELL, *Collector.*

Hon. EDGAR WEEKS.

STATEMENT OF SHIPMENTS TO AND FROM MOUNT CLEMENS ON CLINTON RIVER, MICHIGAN, DURING THE SEASON OF 1879.

Lumber	feet, b. m.	3,623,148
Logs	do	3,300,000
Staves		6,577,950

Shingles		1,700,000
Lath		605,500
Headings	bbls..	18,000
Stave-bolts	cords..	3,500
Cord-wood	do...	5,000

Names of steam and sailing vessels employed in the commerce of Clinton River, Michigan, during the season of 1879.

	Owned at Mount Clemens.	Trading on Clinton River.
Steamer	Ida	Tug T. J. Noyes.
Steam-barges	Florence	Monitor.
	Mayflower	Lewis Gilbert.
	Ida Burton	Rouge.
		Mackinaw.
Steam-yachts	Euna	
	Marietta	
Scows	Matilda	Garibaldi.
	Snowball	Aunt Ruth.
	Hero	Curlew.
		Forrester.
		Handy Boy.

On stocks and building.

One steam-barge by Hall & Kandt, Mount Clemens.
One steam-barge by Lacroix & Chapoton, Mount Clemens.

APPENDIX H H.

ENLARGEMENT OF SAINT MARY'S FALLS CANAL AND IMPROVEMENT OF SAINT MARY'S RIVER, MICHIGAN—CONSTRUCTION OF HARBOR OF REFUGE ON LAKE HURON—IMPROVEMENT OF DETROIT RIVER.

REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, BVT. MAJ. GEN., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

(For letter of transmittal see Appendix W.)

H H 1.

IMPROVEMENT OF SAINT MARY'S RIVER AND SAINT MARY'S FALLS CANAL, MICHIGAN.

This work has progressed very favorably during the past fiscal year. The masonry of the new lock was completed and the machinery for operating it is nearly entirely in place. The dredging at the head of the canal and just above the new lock has made favorable progress. The timber work has been delayed by the failure of every contractor to deliver the timber in time. This is due partly to the high rates of freight during the last season, but chiefly to the fact that the past winter was exceedingly unfavorable for the operations of the lumbermen.

The work to be done during the present year consists in completing the excavation of the prism of the canal and its revetment; building the lock gates; completing the machine-house; grading the grounds; laying the slope walls; building a movable dam at the head of the canal, and guard-gates at the head of the old locks.

The survey of the river was completed during the year and its improvement begun in September, 1879. Three dredges and a drill scow are now engaged in improving the river, and as soon as I receive authority to expend the appropriation made by act of Congress approved June 14, 1880, I will place the cut through Lake George under contract.

The clause in this act relating to this canal includes in the appropriation the cost of operating the canal in case it is turned over to the general government, and at the same time authorizes the Secretary of War after such transfer to draw his warrant on the Secretary of the Treasury to pay the actual expenses of operating and keeping the canal in repair.

I presume the latter method will be pursued, as it is the same as the one that has been adopted for the Louisville and Portland Canal.

If no unforeseen serious accident or delay occurs I confidently hope to be able to pass vessels through the new lock early next season.

In order to complete the work on the canal and river according to the project, the sum of $150,000 will be necessary, and as the full benefit of the new lock can only be obtained by the improved river, this whole sum should be appropriated for the fiscal year ending June 30, 1882.

The original estimate of the cost of this work was $2,460,000.

The whole amount appropriated since this improvement was begun is as follows, viz:

1870	$150,000
1871	350,000
1872	300,000
1873	200,000
1874	200,000
1875	200,000
1876	130,000
1878	175,000
1879	300,000
1880	250,000
Total	2,255,000

Of this amount about $786,000 was expended before, during, and since the excavation of the pit for the new lock in widening and deepening the prism of the canal, revetting its sides, purchase of additional land, straightening the canal, and building new south pier at the head and the survey and improvement of the river.

Of the other $1,469,000 about $1,012,000 has been expended on the lock; about $457,000 was on hand at the end of the fiscal year. The $250,000 appropriated by Congress at its last session has not yet been made available.

Of the amount on hand at the end of the fiscal year the sum of $207,000 is covered by liabilities under contracts, and is therefore not available for the work which still remains to be done.

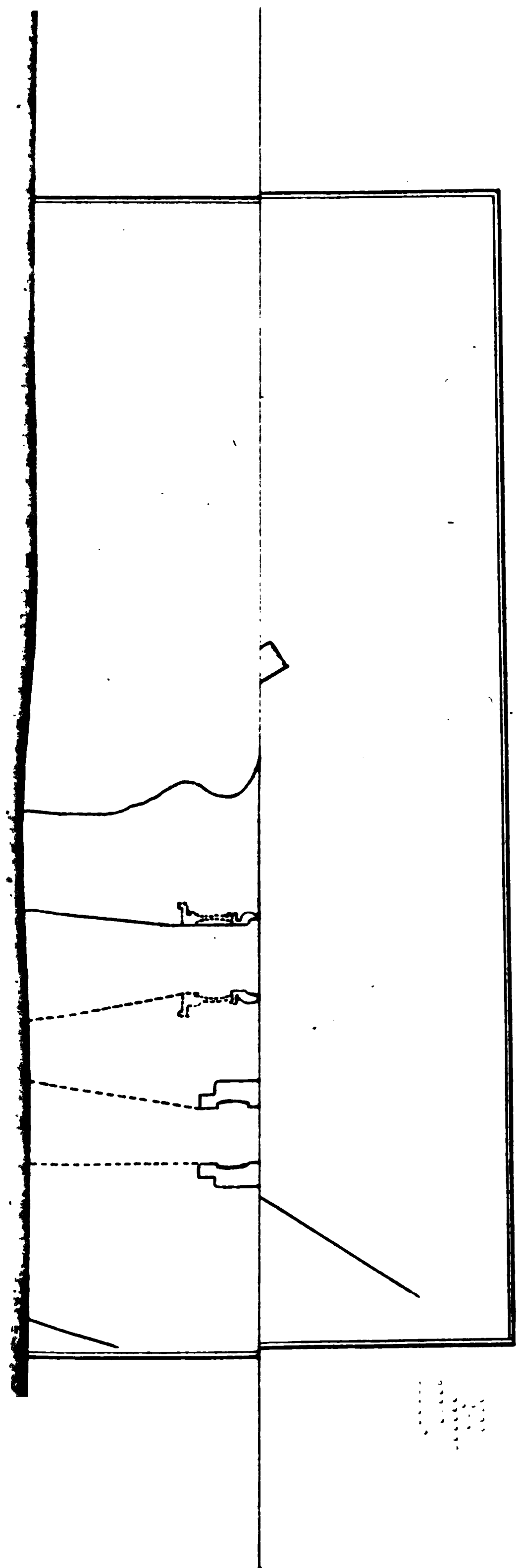
The appended report of Mr. Alfred Noble, who has been assistant engineer in local charge of this work from its commencement, gives the progress in more detail, and in connection with my last three annual reports gives a complete history thereof.

This work is located in the Superior collection district, Michigan, at the Sault Ste. Marie, subport of entry and a short distance from Fort Brady. The nearest light-house is at Round Island, and the nearest port of entry is Marquette, Mich. The amount of revenue collected in the Superior district during the last fiscal year was $12,345.82.

The whole commerce of the great chain of northern and northwestern lakes will be benefited by the completion of this work.

Money statement.

July 1, 1879, amount available	$435,781 31	
Amount appropriated by act approved June 14, 1880	250,000 00	
		$685,781 31
July 1, 1880, amount expended during fiscal year		228,296 11
July 1, 1880, amount available		457,485 20
Amount (estimated) required for completion of existing project		150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		150,000 00



the river and bay were separated by extensive shoals; the town of Monroe is connected with the bay by a railroad about 4 miles long.

Captain Maurice recommended the construction of a harbor of refuge at this locality by building a breakwater of cribs filled with stone, at a cost of $6,296.61.

This plan was approved, and the sum of $3,977.81 was appropriated to carry on the work, by the act of March 2, 1827.

1828.

Operations were commenced in spring of 1828, and by the close of September 1,050 linear feet of the breakwater had been completed; it was the opinion, however, of Captain Maurice that the work should be extended for the proper protection of the harbor, and he recommended the connection of the navigable waters of the bay with those of the Raisin River by means of parallel piers and dredging.

1829.

A survey was made this year to ascertain the practicability and cost of uniting the bay and river as recommended.

An additional appropriation of $2,318 was made by the act of March 3, 1829, and the breakwater was extended 210 linear feet.

1830.

The works were completed this year, a breakwater 1,290 feet long having been constructed at a total cost of $6,261.85; this afforded protection to vessels drawing from 8 to 9 feet water, but the engineer in charge again called attention to the impracticability of communication between the bay and the Raisin River for the ordinary class of vessels navigating the lake, and presented a plan and estimate for opening communication between them.

1831.

On the 4th of October a violent gale destroyed nearly the entire portion of the breakwater that had been built by contract in 1828, but did not injure the part subsequently built by hired labor. The engineer in charge asked for $7,841 to make the necessary repairs.

1832.

An appropriation of $8,000 was made by the act of July 3, 1832, and in September Capt. Henry Smith, of the United States Army, who had succeeded to the charge of the harbor, made a careful examination of the work; he found that the whole of the breakwater, with the exception of 200 feet, had been washed away during the fall and winter of 1831, and that the portion built by contract had been entirely destroyed, leaving but a few stones to mark its position.

1833.

Eight hundred and forty feet of new breakwater was constructed this year.

1834.

An additional appropriation of $4,895 was made by the act of June 28, but, on account of the prevalence of the cholera, but little was done during the year.

1835.

The work was prosecuted to completion this year; the breakwater was now 1,320 feet long, 12 feet wide, and averaging 10 feet in height; the total cost was $19,014.87; the original pier cost $6,295,81; the repairs and reconstruction, $12,719.06.

1836, 1837, 1838.

During the years 1836 and 1837 the work remained in good condition. In 1838 some slight damage was done, and since that time no repairs of any kind have been made. The improvement of the present harbor of Monroe having been commenced, rendering La Plaisance Harbor no longer necessary, the breakwater has gradually been destroyed.

RIVER RAISIN OR MONROE HARBOR.

It was seen at an early day after work had been commenced on La Plaisance Breakwater, that the navigable waters of the river Raisin should be connected with those of the lake, and made available for all vessels then navigating Lake Erie. Captain Maurice several times referred to this subject in his reports, and in 1828, by direction of the Chief of Engineers, he presented a plan and estimate for making direct connection between the river and La Plaisance Bay. Capt. Henry Smith, of the United States Army, who succeeded Captain Maurice, did not agree with him on this subject, and in November, 1834, submitted to the Chief of Engineers a plan for straightening the river Raisin, and making direct connection with the lake.

Captain Smith in this report explained the disadvantages of La Plaisance Harbor, showed how entirely it failed to carry out the end in view, and the great necessity for a direct connection between the lake and the river.

THE RIVER RAISIN.

The river Raisin has its source in Hillsdale County, Michigan, and flows for about 125 miles, measured by its channel, on a course generally easterly, through a very fertile and productive country.

At the time the improvement of the river was inaugurated, it was considered one of the most important streams in Michigan, not only on account of its geographical position, but also for its water power; it had contributed largely towards the prosperity of many enterprising towns along its banks. Monroe, which lies about 40 miles southwest of Detroit and about 3½ miles from the mouth of Raisin River, was at that time a place of some prominence, with 3,000 inhabitants.

PLAN OF IMPROVEMENT.

To make the direct connection with the lake, Captain Smith proposed to cut a canal about 4,000 feet long and 100 feet wide through the peninsula called "River Raisin Point" from the river directly north of House Island to the lake; he proposed to protect the entrance into the

lake by parallel piers 726 feet long and 20 feet wide, running out to a depth of 10 feet; where the canal crossed Sandy Creek he proposed to close the south side and to turn the creek into the canal; the estimated cost of the whole work exclusive of the dredging machine was $55,885.

1835.

The first appropriation of $30,000 was made by the act of February 24, 1835, and work was commenced early in May of that year under the direction of the Chief of Engineers, Capt. H. Smith being in immediate charge; about June 1 a large force of laborers was employed and operations were pushed with so much vigor that during the season nearly one-half of the entire length of the canal was excavated.

The officer superintending the work asked for $60,660 to complete it, giving as a reason for the excess over the original estimate, the high price of labor and the cost of the dredging machine.

1836.

An appropriation of $15,000 was made by the act of July 2, 1836. During this year the operations advanced satisfactorily and were directed as follows:

1. To constructing permanent dams on both sides of the canal to prevent sliding and to secure them from the action of the currents, wash of steamboats, &c.; this work was finished along 1,880 feet of the canal, and partially completed upon the remainder.

2. To continuing the excavation which, with the exception of a few minor details, was completed upon 1,880 feet of the canal.

3. To continuing the construction of the piers on each side of the mouth of the canal to the distance of 450 feet into the lake; these were built by hired labor and purchase in open market. The officer in charge stated that it would require $61,351.50 to complete the work in addition to former appropriations, and gave various reasons for the excess called for over the original estimates.

1837.

An appropriation of $30,000 was made by the act of March 3, 1837. The revetment of the sides of the canal was nearly finished and the excavation was continued, so that by the close of the season 3,387 feet of the canal was completed; the piers were carried out to a depth of 10 feet, the south pier being 597 feet and the north pier 515 feet in length; it was, however, deemed necessary to continue them out to a depth of 12 feet and to construct a beacon on the south pier head.

1838.

An appropriation of $15,000 was made by the act of July 7, 1838. Operations were continued upon the canal prism and the piers; 27,278 cubic yards of earth were excavated from the canal prism and from between the piers in the lake, and about 19,000 yards yet remained to be removed. The north pier was prolonged 60 feet and the south pier 30 feet; it was also found necessary to protect the lake shore on the north side of the canal, where it was rapidly wearing away, by six cribs filled with stone, and to raise the walls of the canal to prevent sand from being washed into the channel.

The officer in charge asked for $54,920 to complete the whole work.

Up to the close of this year the entire appropriations made up to date, amounting to $90,000, had been expended. No further work was done until the year 1844.

1844.

An appropriation of $20,000 was made by the act of June 11, 1844, and the work placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers. An examination of the harbor showed the piers to be in bad condition, and that the lake was making inroads at the angles where the piers joined the shore; materials were collected for making the necessary repairs.

1845.

This year the old piers were thoroughly repaired; 162 linear feet of the old sheet-pile pier was replaced by new crib-work; the north pier was extended 300 linear feet into the lake, and the south pier 90 feet; but the superstructure upon this portion was not completed.

The lake shore at the angles where the piers joined it was protected by a strong crib-work to prevent breaching; repairs were made to the revetment of the United States Canal where Sandy Creek emptied into it. The artificial channel was dredged wherever trouble occurred, 11,684 cubic yards of mud, sand, &c., were removed, and a depth of 9 feet obtained up to a point just below the docks at Monroe. An estimate of $13,303.95 was submitted for completing the unfinished work, prolonging the north pier, and putting in a pier-head.

1852, 1853, 1854.

No appropriations were made nor any work done between the years 1844 and 1852.

By the act of August 30, 1852, $14,000 was appropriated and the money disbursed, in 1853, by a local agent in the repairs of the piers. Capt. Howard Stansbury, of the Topographical Engineers, who assumed charge in 1854, reported that the appropriation had been expended by the agent, before he took charge, in completing 400 feet of the south pier and partially rebuilding 700 feet of the north pier; the latter was left in an unfinished condition, the style of workmanship being rough and defective; he asked for an appropriation of $19,537.77 to put the harbor in order.

No appropriation was made, however, and in 1857 Lieutenant Colonel Graham reported that the works were rapidly deteriorating, and asked for $23,857 to put them in order. No action was taken upon this recommendation, and nothing more was done until 1866.

1866.

In February Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, in accordance with orders from the Chief of Engineers, made a survey of the harbor and submitted a report with an estimate of the cost of its improvement. General Cram made a careful examination of the piers and reported them to be in a dilapidated condition; he recommended that the north pier should be repaired for a length of 665 feet, and the south pier for a length of 180 feet; the heavy ice in the canal and lake prevented any examination as to depth.

Although the revetment of the banks of the canal was decayed and

Abstract of bids received and opened by Maj. G. Weitzel, Corps of Engineers, on September 8, 1879, for furnishing dredges, tugs, and scows for the improvement of Saint Mary's River, Michigan.

No.	Name of bidder.	Residence.	For work to be done off Round Island Point, and between Round Island and Point Iroquois.	For work to be done at shoal, ½ of a mile above Saint Mary's Falls Canal.	Capacity of dredges.
			Per hour.	*Per hour.*	
1	Charles J. De Graw	Fulton, N. Y	$6 00	$7 00	One 800 and one 1,200 yards per day.
2	Charles F. Dunbar	Erie, Pa	9 00	7 00	One with two engines, 10 by 14 inches each; the other with two engines, 8 by 14 inches each.
3	Charles S. Barker	Sault Ste. Marie, Mich.	13 00	7 95	Each 115 horse-power.
4	Williams & Upham	L'Anse, Mich	12 50	12 50	Each 100 horse-power.
5	Starke, Smith & Co.	Milwaukee, Wis.	15 00	12 00	One with two engines, 14 by 14 inches each; the other with two engines, 12 by 14 inches each.
6	Carkin, Stickney & Cram.	East Saginaw, Mich.	14 50	14 00	Each with two engines, 12 by 24 inches each.

Abstract of bids received and opened by Maj. G. Weitzel, Corps of Engineers, on September 26, 1879, for excavating and removing about 77,000 cubic yards of material from Saint Mary's Falls Canal.

No.	Name.	Residence.	Price per cubic yard.
1	Charles S. Barker	Sault Ste. Marie, Mich	$0 35
2	Starke & Smith	Milwaukee, Wis	49½
3	Farris & Garfield	Painesville, Ohio	55
4	Boyle & Roach	Cincinnati, Ohio	55

Abstract of bids received and opened by Maj. G. Weitzel, Corps of Engineers, on January 5, 1880, for furnishing about 90 tons of iron and brass work for the lock-gates of the Saint Mary's Falls Canal, Michigan.

No.	Name.	Residence.	Price per pound.
1	Willard S. Pope	Detroit, Mich	$0 08
2	Detroit Locomotive Works	do	10¼

Abstract of bids for furnishing two dredges, with two tugs and four scows, for improving Saint Mary's River, Michigan, received and opened by Maj. G. Weitzel, Corps of Engineers, on May 3, 1880.

No.	Name.	Residence.	Price per hour.
1	John Hickler	Buffalo, N. Y	$7 48
2	Williams & Upham	L'Anse, Mich	$8 90 & 9 00
3	J. W. Dennis	Buffalo, N. Y	9 50
4	Carkin, Stickney & Cram	East Saginaw, Mich	12 50

Abstract of contracts entered into during fiscal year ending June 30, 1880, for work on the improvement of the Saint Mary's River and Saint Mary's Falls Canal, Michigan.

No.	Name.	Kind of work.	Price.
1	Charles S. Barker	Furnishing dredge	$7 95 per hour.
2	Williams & Upham	......do	12 50 per hour.
3	Charles S. Barker	Excavating in canal	35 per cubic yard.
4	Willard S. Pope	Furnishing iron and brass	08 per pound.
5	John Hickler	Furnishing dredges	7 48 per hour.

REPORT OF MR. ALBERT NOBLE, ASSISTANT ENGINEER.

SAULT STE. MARIE, MICH., *June* 30, 1880.

MAJOR: I have the honor to submit the following report of operations at the Saint Mary's Falls Canal and on the Saint Mary's River during the year ending June 30, 1880.

SAINT MARY'S FALLS CANAL.

At the beginning of the year there were five contracts existing, one with Boyle & Roach for furnishing stone for backing and laying the masonry of the new lock, and for filling earth behind the walls; one with Henry Van Vleck for furnishing face stone for the lock; one with Charles S. Barker for dredging for the enlargement at the head of the canal; one with Larkin & Patrick, and one with E. A. Wetmore & Co., for timber for pier revetment.

A contract was made with Charles S. Barker, October 11, 1879, for excavation for the entrance to the new lock, and one with Willard S. Pope, January 9, 1880, for furnishing the iron-work for the lock-gates.

By hired labor and the purchase of materials in open market the construction and placing of the operating machinery for the new lock were commenced and nearly completed; the stone required for the construction of the machine-house and movable dam and a part of the timber required for the lock-gates procured; the construction of a dam at the head of the canal commenced; by hired labor and the purchase of timber by contract the construction of the pier revetment was continued.

The amounts of work performed and material received during the year under the several contracts were as follows:

Under the contract of May 29, 1875, 1,545.19 cubic yards of masonry have been laid and 26,765.12 cubic yards of earth filling placed behind the walls of the new lock, completing the contract.

Under the contract of May 11, 1876, 2,868.99 cubic feet of face stone have been received, completing the contract.

Under the contract of July 9, 1877, 23,978 cubic yards of earth and bowlders have been excavated.

Under the contract of November 8, 1878, 28,764 cubic feet of timber have been received.

Under the contract of October 11, 1879, 31,108 cubic yards of earth and bowlders have been excavated.

Under the contract of January 9, 1880, 169,896 pounds of iron-work have been received.

In the superstructure of the new southwest pier 27,470 cubic feet of timber have been placed; 7,186 cubic yards of earth and stone have been filled in the pier, and 14,500 cubic yards of earth and stone have been filled behind the pier; 7,086 cubic yards of the old southwest pier have been dredged out.

For the construction of the masonry for a movable dam 1,523 cubic feet of stone were purchased.

For the construction of the gates and miter-sills of the new lock 43,578 feet (board measure) of oak timber were purchased.

To complete the improvement according to existing projects the improvement of the upper entrance is to be completed, the movable dam to be built, the excavation above and below the new lock to be made, the lock-gates built, the operating machinery, machine-house, and pier revetment completed, guard-gates with their masonry to be built at the head of the old locks, the grounds to be graded, and slope-walls laid.

With the funds available for expenditure during the year ending June 30, 1881, it is proposed to do all the work above described, except the construction of guard-gates and their masonry at the head of the old locks, and the grading and slope-walls. In case the canal should be transferred to the United States, the sum of $25,000 will be reserved for operating expenses and ordinary repairs.

An appropriation of $100,000 is needed for the year ending June 30, 1882, to complete the improvement and pay operating expenses and repairs.

SAINT MARY'S RIVER.

The field work of the survey was completed October 10, 1879. During the winter the entire office force was employed in plotting the work. Though still incomplete the maps were far enough advanced in April to enable me to submit an estimate of the cost of making a 16-foot channel from Lake Superior to Lake Huron. In this estimate the cost of improving the channel through the East Neebish Rapids was not included, that improvement having been undertaken several years ago by the Canadian Government.

As soon as possible after commencing the survey dredges were employed to deepen the channel.

The contracts existing for this work are three in number, as follows: with Charles S. Barker, dated September 29, 1879, for one dredge; with Williams & Upham, dated September 30, 1879, for one dredge, and with John Hickler, dated May 13, 1880, for two dredges. The contractor first named is awaiting final payment; the others are still employed.

At this time work has been commenced on five shoals, but not completed on any of them. It is hoped that the funds now available may suffice for the improvement of the channel from Lake Superior to the foot of Sugar Island. The excavation consists of the removal of nearly all kinds of material commonly met, except solid rock, and it is impossible to make a satisfactory estimate of its cost.

An appropriation of $50,000 is needed for the year ending June 30, 1882, with which, if no unforeseen difficulties are met, it is expected that the work will be completed.

A tracing showing the present condition of the improvement of the canal and a diagram showing the stage of water above and below the locks accompany this report.

Very respectfully, your obedient servant,

ALFRED NOBLE,
Assistant Engineer.

Maj. G. WEITZEL,
Corps of Engineers, U. S. A.

SURVEYS OF THE NAVIGABLE CHANNEL OF SAINT MARY'S RIVER, MICHIGAN, AND OF THE APPROACHES FROM LAKE SUPERIOR TO SAINT MARY'S FALLS CANAL, FOR A SIXTEEN-FOOT CHANNEL.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., April 27, 1880.

GENERAL: I have the honor to state that the act making appropriations for the construction, repair, preservation, and completion of certain works on rivers and harbors, and for other purposes, contained the following clause:

> For improving Saint Mary's River and Saint Mary's Falls Canal, three hundred thousand dollars, of which sum two hundred thousand dollars shall be expended on the canal, and one hundred thousand dollars shall be expended on the survey and improvement of the river towards obtaining a depth in present channel of sixteen feet.

The circular letter from the office of the Chief of Engineers dated April 5, 1879, informed me of this fact and directed me to furnish a project for the expenditure of the money. I submitted the project with letter dated April 9, 1879, and in another letter of same date I requested authority to proceed with the survey as soon as navigation opened.

But I did not receive the authority, and it was only on May 31, 1879, that I was directed to proceed with the survey by a telegram from your office.

The party was promptly organized and took the field properly equipped on June 20, 1879.

The following is a copy of the report of Mr. Alfred Noble, who was in charge of the work, to me:

DETROIT, MICH., *April* 23, 1880.

MAJOR: I have the honor to submit the following report on the survey of the naviable channel of the Saint Mary's River and the Middle Neebish outlet from Hay Lake,

and an estimate of the cost of removing obstructions in the navigable channel to a depth of 16 feet below the water's surface.

The field work was commenced on June 20, 1879, and completed October 11, 1879.

* * * * * * *

From the lake-survey charts and from the reports of navigators it appeared that there were three localities above the Saint Mary's Falls Canal requiring improvement; that there was deep water in the upper part of Lake George and from the head of Mud Lake, at Sailors' Encampment, to Lake Huron. It was necessary to survey a distance, measured in the direction of the channel, of 0.6 of a mile across the shoal between Round Island and Point Iroquois, a distance of 1 mile across the shoal off Round Island Point, a distance of 2.6 miles from Big Point to the head of the Saint Mary's Falls Canal, a distance of 14.4 miles from the foot of the Saint Mary's Falls Canal to deep water at the head of Lake George, a distance of 13.8 miles from deep water at the head of the flats in Lake George to Mud Lake, and to complete the survey of the Hay Lake channel, a distance of 5.6 miles from deep water in Hay Lake through the Middle Neebish Rapids to the confluence of this channel at the head of Little Mud Lake with the one now navigated, making a total distance of 38 miles.

The triangulation was also extended through the West Neebish in order to locate borings taken to complete the survey of 1873.

The Canadian Government has prosecuted the improvement of the East Neebish Rapids for four years. I was informed by the resident engineer that it was proposed to continue it. No soundings were taken, therefore, for a distance of 2,500 feet through the most rapid part.

A system of triangulation was extended along the river and enough additional stations built to locate the shore line and the soundings. No topography was taken except along the shore line.

The channel navigated by vessels was included between two parallel lines of buoys from 500 to 1,500 feet apart; at the greater width a center line of buoys was usually set. It was sought to include all the area through which there was any probability of locating the channel to be improved. The area thus included was sounded by the time-sounding method When time soundings showed a less depth than 22 feet over stony bottom, or less than 20 feet over sand or clay, the area of shoal water was sounded from the raft. This raft was 16 feet by 100 feet; it was attached by a line 1,500 to 2,500 feet long to a small scow anchored in the stream as near the channel as practicable. Suspended from the raft was a line of iron bars which could could be lowered to any desired depth (16 feet or less) below the surface of the water. The "swinging line" connecting the raft and scow was attached to one end of the raft. At distances of 25 feet from each other along one side of the raft four rodmen were stationed, who took soundings at intervals of 15 seconds as the raft was pushed across the channel by a small tug. At each sounding the direction of the raft was noted by compass-reading. A staff at the center of the raft was located each fourth sounding by two transit readings by observers ashore. After crossing the channel the tug was changed to the opposite side of the raft, 75 feet of swinging line paid out and a new area across the channel sounded. In this way not only were a large number of soundings taken and located with considerable accuracy, but any scattered bowlders with less than 16 feet of water on them were located by the bars.

At a few places where the presence of rock was known or suspected, enough borings were made to estimate its amount approximately.

Water-gauge readings were taken at two places at intervals of 15 minutes during the working hours. One observer was stationed at the Saint Mary's Falls Canal; the other near the work. New gauges were established as the work progressed. The difference between the assumed stage of reference at the canal and the mean stage at the canal for the time that any one gauge at the work was occupied, was applied to the mean of the readings of the gauge at the work to determine the surface of reference at that gauge. The difference between the mean surface of the water at the work for any half day, and this surface of reference, was applied as a correction to the soundings taken during that half day.

The stages of reference at the canal are as follows:

At the head of the canal 116.00′ above canal datum.

At the foot of the canal 98.50′ above canal datum.

The triangulation of the survey above Point Aux Pino was not connected with the remainder. One line was measured. For the remainder of the triangulation, five lines were measured.

The lines were measured with a 500-foot steel tape; each line was measured twice and the measurements corrected for temperature, with the following results:

Line.	First measurement, corrected to 62°.	Second measurement, corrected to 62°.	Mean.	Correction for grade.	Length of line.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
△3–△5	2,219.375	2,219.025	2,219.200	—0.005	2,219.195
△11–△13	3,122.409	3,122.425	3,122.417	—0.175	3,122.242
△19–△21	7,127.503	7,127.595	7,127.549	—0.078	7,127.471
△36–△38	9,116.650	9,116.807	9,116.728	—0.061	9,116.667
△55–□51	3,044.088	3,044.075	3,044.082	—0.007	3,044.075
△76–△78	7,990.747	7,990.721	7,990.734	—0.091	7,990.643

No raft soundings were taken in the Middle Neebish outlet from Hay Lake.

Soundings were taken along a cork line through the most rapid part of Middle Neebish for a distance of 1 mile.

* * * * * * *

ESTIMATE.

It is desired to have as great a depth of water through the river as through the canal. It is known that the difference of the water's surface at the foot of the canal and at the foot of Lake George was 1 foot less in August, 1879, than in August, 1874. The soundings are referred to a surface of reference parallel to the surface of 1879. To insure a depth through the river as great as that through the canal, there must be an allowance made for the difference in inclination of the surface of the river.

This estimate is based on a depth below the surface of reference of 16.00′ above the canal; 16.25′ from Topsail Island to Farmer's Ridge; 16.50′ in Little Lake George, and 17.00′ from Church's to the Sailors' Encampment.

The maps of the Middle Neebish outlet of Hay Lake are not yet completed, and this estimate includes only the obstructions in the channel now navigated.

No. 1, 1¼ miles above Round Island	$3,000
No. 2, off Round Island Point	8,000
No. 3, below Big Point	5 000
No. 4, above Topsail Island	2,014
No. 5, above Topsall Island	9,498
No. 6, between Marchand's and Jenkin's Reefs	6,498
No. 7	1,313
No. 8, near channel buoy 53	336
No. 9	1,982
No. 10	833
No. 11	228
No. 12	1,215
No. 13 } near Farmer's Ridge buoy	1,448
No. 14 } near Farmer's Ridge buoy	450
No. 15 } near Farmer's Ridge buoy	180
No. 16, in Little Lake George	230
No. 17, in Little Lake George	1,060
No. 18, in Little Lake George	3,072
No. 19, above Church's, north side of channel	500
No. 20, above Church's, south side of channel	1,200
No. 21, Lake George above the natural cut	43,500
No. 22, Lake George below the natural cut	36,600
No. 23, off Stribling's Point	960
No. 24, above Green's Point	11,250
No. 25, off Point of Woods	10,500
No. 26, off Mirr's Point	21,000
No. 27, at Sailors' Encampment	10,000
	181,867
Add 15 per cent. for superintendence and contingencies	27,280
Total	209,147

This estimate is for a 300-foot channel through all the obstructions except Nos. 21 and 22, where it is proposed to make a channel 250 feet wide. No estimate is made for the improvement of the East Neebish Rapids. The obstructions Nos. 1, 19, 20, 23, and 24, consist of sand, clay, and bowlders; obstructions Nos. 2 and 5, inclusive, 25 and 26, of bowlders, with a small amount of sand and gravel; Nos. 16, 17, 18, 21, and 22, of sand and clay; No. 27, of bowlders and masses of limestone.

Very respectfully, your obedient servant,

ALFRED NOBLE,
Assistant Engineer.

Maj. G. WEITZEL,
Corps of Engineers, U. S. A.

It will be seen from the above that the opinion expressed by me in my preliminary report, dated January 9, 1880, as to the cost of improving this channel of the Saint Mary's River, to obtain the depth called for in the act of Congress is erroneous in that I placed the cost too high. It is, however, utterly impossible to estimate the cost of such work with absolute accuracy. In this case the cost may not exceed $200,000, and may reach $225,000.

The Canadian Government is engaged in deepening the East Neebish Rapids, and in its official reports leads me to the conclusion that it will improve this part of the channel to a depth of 16 feet. I therefore did not include this in our work.

The amount of money expended on the survey and improvement of the river to date is $28,500. This leaves a balance on hand of $71,500 to continue the work. Assuming, therefore, that the work will eventually cost $225,000, the sum necessary still to be appropriated to complete the work is $150,000, taking into consideration that about $3,500 worth of work has already been done on the improvement.

This entire sum can be economically and judiciously expended during the fiscal year ending June 30, 1881, and I therefore respectfully urge its appropriation.

The new canal will be open to commerce early in the season of 1881, if Congress makes the proper appropriation at its present session. In order to get the full benefit of the improved canal at as early a date as possible, this channel should be improved by that time.

The drawings to illustrate the survey will be transmitted as soon as completed.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

H H 2.

CONSTRUCTION OF HARBOR OF REFUGE AT SAND BEACH, LAKE HURON, MICHIGAN.

The progress of this work during the year has been quite satisfactory when the numerous delays caused by the contractors for timber and stone are taken into consideration.

Nine cribs, 65 by 38 feet, were built and placed in position in 30 feet of water, in extension of the lake arm of the breakwater. The superstructure on the ten cribs sunk during last season has been constructed to 5 feet in height in a length of 144 feet, to 4 feet in height in a length of 308 feet and 2 feet in height in a length of 198 feet, and filled up with

bowlder stone; five grillage bottoms for additional cribs were built; 1,000 linear feet of timber wall 5 feet in height was built from the north entrance eastward, and considerable work in preparing the bottom and drilling large bowlders was done by the diver.

I regret to be compelled again to call the attention of Congress to the imperative necessity of creating the position of master for this harbor. I have repeatedly called attention to this matter. During the severe storm during the night from November 19 to 20, 1879, five lives were lost and considerable property destroyed at the entrance to the harbor, all of which would have been prevented if a master armed with proper authority had been on the ground.

Three contracts were let during the year for furnishing timber and iron for the breakwater and for dredging to increase the capacity of the harbor.

It is proposed to expend the appropriation of $75,000 made by the act of Congress approved June 14, 1880, in extending the lake arm of the breakwater and in dredging in the harbor. This appropriation has, however, not yet been made available.

The estimated cost of this work, according to the original project, was $1,452,550; but, as explained in my annual report for the fiscal year ending June 30, 1877, it will probably cost not to exceed $875,000. Of this amount the following sums have been appropriated:

1871	$100,000
1872	100,000
1873	75,000
1874	75,000
1875	100,000
1876	75,000
1878	100,000
1879	75,000
1880	75,000
Total	775 000

I respectfully recommend that the sum of $100,000 be appropriated to complete this work during the fiscal year ending June 30, 1882.

The appended report of Mr. C. P. Gilbert, assistant engineer, in local charge of the work, gives in detail the operation during the past year, and, in connection with my last annual report, a complete history of the work.

The work is located in the collection district of Port Huron, Mich. The nearest port of entry is Port Huron. A light-house stands on the angle-crib of the breakwater.

The amount of revenue collected in this district during the fiscal year was $207,076.53.

The whole commerce of the great chain of northern and northwestern lakes will be benefited by this work.

Money statement.

July 1, 1879, amount available	$150,791 11	
Amount appropriated by act approved June 14, 1880	75,000 00	
		$225,791 11
July 1, 1880, amount expended during fiscal year		64,861 24
July 1, 1880, amount available		160,929 87
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		100,000 00

Abstract of bids for furnishing timber for crib-work at the Harbor of Refuge, Lake Huron, Mich., received and opened by Maj. G. Weitzel, Corps of Engineers, on November 29, 1879.

No.	Name.	Residence.	Lot 1, per M feet.	Lot 2, per M feet.	Lot 3, per M feet.
1	John W. McGinn	Cheboygan, Mich	$13 88	$13 50	$13 25
2	Farris & Garfield	Painesville, Ohio	14 85	14 85	14 85
3	Hemenway & Hayes	do	16 15	15 90	16 50

Abstract of bids received and opened by Maj. G. Weitzel, Corps of Engineers, on February 2, 1880, for furnishing dredge, tug, and scows for removing shoals at the Harbor of Refuge, Sand Beach, Mich.

No.	Name.	Residence.	Price per hour.
1	Hosea T. Stock	Toledo, Ohio	$7 60
2	John Hickler	Buffalo, N. Y	8 75
3	George M. Case	Fulton, N. Y	9 50
4	Thomas M. Hubbell	East Saginaw, Mich	10 00
5	Orville J. Jennings	Fulton, N. Y	10 00
6	Lee & Dunbar	Buffalo, N. Y	11 00
7	Carkin, Stickney & Cram	East Saginaw, Mich	14 50
8	Williams & Upham	L'Anse, Mich	15 00

Abstract of bids received and opened by Maj. G. Weitzel, Corps of Engineers, on February 2, 1880, for furnishing iron bolts, spikes, and plates for the Harbor of Refuge, at Sand Beach, Mich.

No.	Name.	Residence.	Price per pound.
1	Michigan Bolt and Nut Works	Detroit, Mich	(*)
2	Ducharme, Fletcher & Co	do	$0 04¾
3	George Worthington	Cleveland, Ohio	05
4	Henry D. Hall	Cuyahoga, Ohio	05⅛
5	Christian H. Buhl	Detroit, Mich	05¼
6	Willard S. Pope	do	06

* Informal.

Abstract of contracts entered into during fiscal year ending June 30, 1880, for work at the Harbor of Refuge, Lake Huron, Mich.

No.	Name.	Kind of work.	Price.
1	John W. McGinn	Furnishing timber	$13.25, $13.50, $13.88 per M feet.
2	Hosea T. Stock	Furnishing dredge	$7.60 per hour
3	Ducharme, Fletcher & Co	Furnishing iron	$0.04¾ per pound.

REPORT OF MR. C. P. GILBERT, ASSISTANT ENGINEER.

SAND BEACH, MICH., *June* 30, 1880.

GENERAL: I have the honor to submit the following report of operations at the harbor of refuge for the year ending June 30, 1880.

The work of construction has been continued by the purchase of material under advertised contract and in open market and with hired labor and plant.

The necessary preparations of the crib foundations by means of divers, and the repeated modifications of the plans required by the varying character of the bottom and the increased exposure as the work advances out into the lake, render it impracticable to propose a set of specifications for a contract that would not have to be changed during the progress of a season's work.

The work has thus far been carried on at a less cost than when under contract, and is now quite well supplied with plant and tools.

During the year 1879 eight 65 by 38 foot cribs were constructed and secured in place in 30 feet of water, completing the project for that season of ten cribs without superstructure in extension of the lake arm of the breakwater.

The progress of the work during the entire season was seriously delayed by the continued failure of the contractors for material to furnish it as needed, necessitating the purchase of timber and plank in open market to keep the work going.

One thousand linear feet of timber wall, 5 feet high above the deck, was built along the lake face of the old work from the north entrance eastward. This was built in accordance with your instructions as an attempt to prevent the heavy flow of water over the top of the pier during severe gales. This washing of heavy seas across the top of the breakwater made it very dangerous and frequently impossible for sailors to land upon the breakwater during heavy storms for the purpose of making their lines fast. The extra wall is a decided success, and meets great favor from vessel men.

A partial preparation of the foundation for next season's cribs was made by the diver.

Timber for five grillages was stored over winter to commence work upon in spring.

It was not thought best to employ a dredge during the season of 1879, owing to the late date at which the appropriation approved March 3, 1879, was made available.

The work here was closed for the season November 15, and placed in charge of a watchman. On the night of November 19, 1879, a very severe storm occured on Lake Huron, during which six barges and vessels were driven ashore from the east side of the harbor upon the reef below, with a loss of five lives and the total destruction of two barges. It is the decided opinion of all who witnessed the occurrence that the presence of a properly authorized harbor master, by compelling the vessels to take proper places in the harbor, would have entirely prevented this loss of life and property.

Preparations were made during the winter for continuing the survey of the lake bottom inside the harbor by sounding through holes cut in the ice, but the entire failure of ice prevented the carrying out of this important project.

In 1880 the work of construction was commenced April 15, working upon the timber stored over winter and purchasing in the spring.

The timber contractor having failed to furnish any timber by June 1, the date required by the contract, under authority from you I purchased timber in small lots in open market to keep the work going, and with the exception of a small lot of less than 50,000 feet furnished by contractor June 17, the work has so far been carried on in this way, and progress made as follows:

The grillage bottoms for five cribs have been built and launched ready for building up, and one 65 by 38 by 31 foot crib completed, sunk in place, and filled with bowlder stone. Sixty-four thousand three hundred and eighty feet board measure timber has been framed ready to build into cribs. The superstructure walls over the ten cribs sunk last season have been built up as follows: 144 linear feet to 5 feet in height, 308 linear feet to 4 feet in height, 198 linear feet to 2 feet in height, and all filled with bowlder stone.

The settlement of these cribs during the winter was quite satisfactory.

The supply of bowlder stone is more than double that of last season, and will be ample for the season's work. Two hundred and ten cords were delivered by the handpickers in their own boats on the day of sinking the first crib.

The dredge contracted for arrived on the 12th of June, and commenced work on the 14th. On the 16th the boiler failed completely, and it was taken below for repairs.

The diver has drilled and blasted with dynamite to a size for the dredge to handle twenty-one large bowlders inside the harbor.

At the beginning of the year there were two contracts existing. One with Farris & Garfield for furnishing timber, and one with Orville J. Jennings for furnishing limestone. Final estimate under the former was given November 20, 1879. The contract with Orville J. Jennings was annulled after he had refused to complete it.

During the year proposals for furnishing material and plant under advertised contract were received and accepted as follows: November 29, 1879, for furnishing timber and plank, from John W. McGinn, of Cheboygan, Mich.; February 2, 1880, for furnishing iron, from Ducharme, Fletcher & Co., of Detroit, Mich.; February 2, 1880, for furnishing dredge, tug, and dump scows, from Hosea T. Stock, of Toledo, Ohio.

These contracts, with the necessary labor to put the material in place, will exhaust the appropriation approved March 3, 1879, and complete the project for the season of 1880, as submitted in report of last year.

It is proposed to expend the appropriation of $75,000 approved June 14, 1880, in extending the lake arm of the breakwater by additional 65 by 38 foot cribs, without superstructure, in building a complete superstructure over the cribs sunk in place under appropriation approved March 3, 1879, and in continuing the work of dredging inside the harbor.

The appropriation asked for for the year ending June 30, 1882, should be expended in the same way.

The dimensions of the work now in place are as follows: From north entrance to

east end, 3,445 linear feet; complete east of north entrance, 2,730 linear feet; cribs with incomplete superstructure, 650 linear feet; cribs without superstructure, 65 linear feet; complete west of north entrance, 1,500 linear feet; total length in place, 4,945 linear feet. Portion of projected length in place, 70 per cent.

Total material in place in the work, 11,393,362 feet, board measure, timber and plank, 923,536 pounds iron, 35,005 cords of stone, which amounts are 63 per cent. of the timber and plank, 71 per cent. of the iron, and 65 per cent. of the stone required for the total length projected.

A tabulated statement of the lake craft using the harbor during the year is annexed.

Very respectfully, your obedient servant,

C. P. GILBERT,
Assistant Engineer.

General G. WEITZEL,
Major, Corps of Engineers.

Tabulated record of lake craft taking refuge in the harbor from June 30, 1879, to June 30, 1880.

Month.	Direction of wind at time of entering.																								Totals.			Grand totals.
	N.			N. W.			W.			S. W.			S.			S. E.			E.			N. E.						
	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	Steam.	Sail.	Tow.	
1879.																												
July	....	3	....	1	1	....	1	7	1	2	1	1	....	....	....	1	1	1	3	4	1	5	6	5	13	23	9	45
August	7	15	10	5	....	8	....	....	....	4	3	2	2	4	....	2	....	....	....	....	....	6	6	8	26	28	28	82
September	6	4	6	27	33	29	3	1	....	13	16	1	7	5	4	8	12	8	2	1	....	1	2	....	67	74	48	189
October	7	1	....	23	23	16	....	3	....	10	8	12	17	11	9	3	7	8	....	....	....	1	1	1	61	54	46	161
November	....	....	....	32	11	48	22	13	15	30	27	27	8	1	7	13	6	8	....	....	....	6	1	4	111	59	109	279
December	....	....	....	....	....	....	....	....	....	6	3	4	....	....	....	2	....	....	2	....	....	8	....	5	18	3	9	30
1880.																												
March	1	1	....	3	....	....	....	....	....	....	....	....	....	....	....	1	....	....	1	....	....	1	....	....	7	1	....	8
April	13	4	7	9	2	13	5	4	7	27	21	32	....	....	....	3	2	....	2	1	....	22	10	22	81	44	81	206
May	3	7	3	2	6	....	7	22	11	13	5	12	....	....	....	11	6	....	....	....	....	19	6	6	55	52	32	139
June	6	1	3	....	....	....	12	5	10	9	8	14	6	4	11	3	6	....	....	....	....	....	....	....	36	24	38	98
Totals	43	36	29	102	76	114	50	55	44	114	92	105	40	25	31	47	40	25	10	6	1	69	32	51	475	362	400	1,237
Grand totals	108			292			149			311			96			112			17			152			1,237			

During the year the drilling and blasting have been carried over an area of 139,370 square feet. In this area 12,121 cubic yards of rock have been broken, and there have been removed by dredging 8,401 cubic yards of rock. Of the above total the amounts done under the two contracts are as follows:

Under contract dated October 21, 1878:

Area drilled and blasted	square feet	77,070
Rock broken	cubic yards	5,725
Rock dredged	do	6,680

Under contract of February 19, 1880:

Area drilled and blasted	square feet	62,300
Rock broken	cubic yards	6,396
Rock dredged	do	1,721

It appears, therefore, that the drilling and blasting is about completed under both contracts, and the dredging under the first contract. In general the work is carried on as rapidly as the circumstances will permit. Some delay is caused by the failure to reach grade in all cases by the first blasts, rendering it necessary to go about from point to point with the drill scow and blast a second time. This failure has resulted from the peculiar formation of the rock, which, at the depth reached by the drill, in getting grade in some places is soft and yields readily to the explosive and diminishes its effect upon the large covering layer of rock.

In some parts of the work last year it appeared that the original estimates were insufficient. A resurvey of the whole ground shows that this difference was only a partial and local one, and the quantity now computed does not differ from the original estimate in its aggregate. The soundings on this resurvey were taken as before with a sounding float and they are as accurate as can be made. They show that there remains to be removed a quantity of 42,819 cubic yards, which, at $7 per yard, will cost in round numbers $300,000. There is already appropriated for the coming year $50,000, which leaves to be appropriated for the completion of the work $250,000. There are some special reasons why this work should be hastened to an early completion, say within three years. The locality of the work is in the track of all the vessels passing through the Detroit River. In its prosecution the blasting and the dredging which are necessarily carried on in different places both leave projections and ridges of rock which, for the time, are an additional obstruction. A continuation of the work longer than necessary, therefore, prolongs the difficulty, with no advantage in point of economy. The balance required to finish the work can be well expended in two years.

The number of vessels that struck on the crossing during the year since September 4, 1879, was thirty. The number of vessels detained at the crossing from October 17, to November 14, 1879, was seventy-three. The average length of detention was twenty hours.

The accompanying tracing shows the present condition of the work.

Very respectfully, your obedient servant,

BENJ. D. GREENE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers.

1852, 1853, 1854, 1855, 1856.

An appropriation of $15,000 was made by the act of August 30, and the work was placed in charge of Capt. H. Stansbury, of the Corps of Topographical Engineers.

An examination of the harbor showed about the same depth as was found in 1848, but Peninsula Point was being rapidly washed away, the northern gales having made several breaches and greatly reduced its area.

The appropriation of August 30, 1852, was devoted during the year 1853 and 1854 to constructing along the line of the peninsula for its protection a rough crib-work 3,357 feet long. Captain Stansbury stated in his annual report in September, 1855, that this crib-work was answering its purpose admirably, and that the peninsula had increased in width and height; he asked for the sum of $112,117 for closing the breach between the "peninsula and main shore," and for completing the crib-work protection along the entire outer portion of the peninsula; this recommendation was repeated in his annual report for 1856.

1857, 1858, 1859.

Maj. and Bvt. Lieut. Col. J. D. Graham, of the Corps of Topographical Engineers, assumed charge of the harbor in 1857, and repeated the recommendation of Captain Stansbury. No action was taken upon these recommendations, and during the winter of 1859 the crib-work was nearly all destroyed.

1862.

A new survey of the harbor was made under the direction of Col. J. D. Graham in 1862; the outer bar maintained about the same distance from Cedar Point, but a narrow channel had worked through to the northwest with a depth of 13 feet while there was a depth of 12 feet on the bar inside of Cedar Point; there was considerable change in the shape and depth of the channel near Cedar Point; it is possible that the soundings during this survey were not referred to the same zero as those previously made, and this may account for the increased depth shown on the chart.

1864.

In October 1864, Col. T. J. Cram, lieutenant-colonel Corps of Engineers, submitted a report in which he recommended the dredging of the outer bar so as to get a straight channel 400 feet wide and 12 feet deep, and the construction, if found necessary, of parallel piers, 400 feet long, to maintain the channel; the estimated cost of the work was $38,580.

The channel through the outer bar at this time presented a depth of about 10 feet.

1866.

An appropriation of $38,580 was made by the act of June 23, 1866, and General Cram recommended that it should be applied to dredging a channel 400 feet wide and 12 feet deep through the outer bar. A contract was made for this work in October, 1866, at the rate of 75 cents per cubic yard.

1867, 1868.

Operations were commenced in June, 1867, and continued under the contract of October, 1866, through the seasons of 1867 and 1868, during

which time 24,317 cubic yards of sand were removed from the channel through the outer bar.

1869.

General Cram was relieved in April, 1869, by Maj. W. McFarland, of the Corps of Engineers.

The channel through the outer bar was examined in June and found to be 240 feet wide with a depth of 12 feet, except at two localities where, for a short distance, it was only 11½ feet deep. As the depth on the outer bar was greater than on the inner one, Major McFarland recommended that the remainder of the appropriation should be applied to deepening the channel through the inner bar, and a contract was made in August for this purpose at 33½ cents per cubic yard. The heavy gales in the fall of 1869 prevented work during the year.

1870.

Operations were commenced in July and continued until the close of November, and a channel 2,500 feet long, 60 feet wide, and 12 feet deep was opened through the inner bar by removing 28,192 cubic yards of sand, &c.

An appropriation of $10,000 was made by the act of July 11, 1870.

1871.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, in April, 1871.

In March a contract was made for cutting a channel through the inner bar one-half mile long, 90 feet wide, and 12 feet deep, at 26½ cents per cubic yard in position; operations were commenced in May, and by the close of the season 30,784 cubic yards of sand and clay had been removed.

1872.

An appropriation of $13,000 was made by the act of June 10, 1872.

A survey of the bay was made this season under the direction of General C. B. Comstock, the officer in charge of the survey of the lakes; a depth of 13 feet was found in the channel through the outer bar, and of about 11 feet through the inner bar. A contract was made for continuing the dredging through the inner bar, at 34 cents per cubic yard, and 34,000 cubic yards of sand, clay, &c., were removed during the season.

1873.

In January, 1873, Colonel Gillespie submitted an elaborate report, with a chart and plan of improvement for keeping the channel open through the inner and outer bars; the estimated cost of the whole work was nearly $1,000,000; he believed that any unprotected channel through the bay would gradually fill up; he recommended that the channel through the outer and inner bars should be deepened to 14 feet to the center of the area of deep water inclosed by the 12-foot curve in the bay, and estimated the cost of this part of the work at $50,000. The recommendation for deepening the channel was approved by the Chief of Engineers, and an appropriation of $25,000 was made by the act of March 3, 1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873.

APPENDIX I I.

IMPROVEMENT OF HARBORS ON LAKE ERIE WEST OF DUNKIRK.

REPORT OF MAJOR JOHN M. WILSON, CORPS OF ENGINEERS, BVT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, July 1, 1880.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1880.

I am, general, very respectfully, your obedient servant,

JOHN M. WILSON,
Major of Engineers,
Brevet Col., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

I I 1.

IMPROVEMENT OF MONROE HARBOR, MICHIGAN.

HISTORY OF THE HARBOR.

The harbor of Monroe, Mich., is situated at the extreme westerly bend of Lake Erie, about 1½ miles west of the mouth of the Raisin River, and about 3½ miles from the town of Monroe.

The attention of the general government was first called to this locality by the act of Congress approved May 20, 1826, wherein an appropriation of $200 was made for "the survey of La Plaisance Bay, in the Territory of Michigan, to ascertain the expediency of improving the navigation thereof and the expense of effecting the same."

LA PLAISANCE BAY.

La Plaisance Bay is situated about 2 miles to the eastward of the present entrance to the harbor of Monroe.

The survey ordered by the act of Congress was made by Capt. T. W. Maurice, of the Corps of Engineers, who reported that the bay was broad and shallow, the greatest depth available being 9 or 10 feet, and that it was surrounded on all sides, except the lake, by a marsh about 1 mile broad; the river Raisin, upon which the town of Monroe is situated, was connected with the bay near it head, but the navigable waters of

the river and bay were separated by extensive shoals; the town of Monroe is connected with the bay by a railroad about 4 miles long.

Captain Maurice recommended the construction of a harbor of refuge at this locality by building a breakwater of cribs filled with stone, at a cost of $6,296.61.

This plan was approved, and the sum of $3,977.81 was appropriated to carry on the work, by the act of March 2, 1827.

1828.

Operations were commenced in spring of 1828, and by the close of September 1,050 linear feet of the breakwater had been completed; it was the opinion, however, of Captain Maurice that the work should be extended for the proper protection of the harbor, and he recommended the connection of the navigable waters of the bay with those of the Raisin River by means of parallel piers and dredging.

1829.

A survey was made this year to ascertain the practicability and cost of uniting the bay and river as recommended.

An additional appropriation of $2,318 was made by the act of March 3, 1829, and the breakwater was extended 210 linear feet.

1830.

The works were completed this year, a breakwater 1,290 feet long having been constructed at a total cost of $6,261.85; this afforded protection to vessels drawing from 8 to 9 feet water, but the engineer in charge again called attention to the impracticability of communication between the bay and the Raisin River for the ordinary class of vessels navigating the lake, and presented a plan and estimate for opening communication between them.

1831.

On the 4th of October a violent gale destroyed nearly the entire portion of the breakwater that had been built by contract in 1828, but did not injure the part subsequently built by hired labor. The engineer in charge asked for $7,841 to make the necessary repairs.

1832.

An appropriation of $8,000 was made by the act of July 3, 1832, and in September Capt. Henry Smith, of the United States Army, who had succeeded to the charge of the harbor, made a careful examination of the work; he found that the whole of the breakwater, with the exception of 200 feet, had been washed away during the fall and winter of 1831, and that the portion built by contract had been entirely destroyed, leaving but a few stones to mark its position.

1833.

Eight hundred and forty feet of new breakwater was constructed this year.

1834.

An additional appropriation of $4,895 was made by the act of June 28, but, on account of the prevalence of the cholera, but little was done during the year.

1835.

The work was prosecuted to completion this year; the breakwater was now 1,320 feet long, 12 feet wide, and averaging 10 feet in height; the total cost was $19,014.87; the original pier cost $6,295,81; the repairs and reconstruction, $12,719.06.

1836, 1837, 1838.

During the years 1836 and 1837 the work remained in good condition. In 1838 some slight damage was done, and since that time no repairs of any kind have been made. The improvement of the present harbor of Monroe having been commenced, rendering La Plaisance Harbor no longer necessary, the breakwater has gradually been destroyed.

RIVER RAISIN OR MONROE HARBOR.

It was seen at an early day after work had been commenced on La Plaisance Breakwater, that the navigable waters of the river Raisin should be connected with those of the lake, and made available for all vessels then navigating Lake Erie. Captain Maurice several times referred to this subject in his reports, and in 1828, by direction of the Chief of Engineers, he presented a plan and estimate for making direct connection between the river and La Plaisance Bay. Capt. Henry Smith, of the United States Army, who succeeded Captain Maurice, did not agree with him on this subject, and in November, 1834, submitted to the Chief of Engineers a plan for straightening the river Raisin, and making direct connection with the lake.

Captain Smith in this report explained the disadvantages of La Plaisance Harbor, showed how entirely it failed to carry out the end in view, and the great necessity for a direct connection between the lake and the river.

THE RIVER RAISIN.

The river Raisin has its source in Hillsdale County, Michigan, and flows for about 125 miles, measured by its channel, on a course generally easterly, through a very fertile and productive country.

At the time the improvement of the river was inaugurated, it was considered one of the most important streams in Michigan, not only on account of its geographical position, but also for its water power; it had contributed largely towards the prosperity of many enterprising towns along its banks. Monroe, which lies about 40 miles southwest of Detroit and about 3½ miles from the mouth of Raisin River, was at that time a place of some prominence, with 3,000 inhabitants.

PLAN OF IMPROVEMENT.

To make the direct connection with the lake, Captain Smith proposed to cut a canal about 4,000 feet long and 100 feet wide through the peninsula called "River Raisin Point" from the river directly north of House Island to the lake; he proposed to protect the entrance into the

lake by parallel piers 726 feet long and 20 feet wide, running out to a depth of 10 feet; where the canal crossed Sandy Creek he proposed to close the south side and to turn the creek into the canal; the estimated cost of the whole work exclusive of the dredging machine was $55,885.

1835.

The first appropriation of $30,000 was made by the act of February 24, 1835, and work was commenced early in May of that year under the direction of the Chief of Engineers, Capt. H. Smith being in immediate charge; about June 1 a large force of laborers was employed and operations were pushed with so much vigor that during the season nearly one-half of the entire length of the canal was excavated.

The officer superintending the work asked for $60,660 to complete it, giving as a reason for the excess over the original estimate, the high price of labor and the cost of the dredging machine.

1836.

An appropriation of $15,000 was made by the act of July 2, 1836. During this year the operations advanced satisfactorily and were directed as follows:

1. To constructing permanent dams on both sides of the canal to prevent sliding and to secure them from the action of the currents, wash of steamboats, &c.; this work was finished along 1,880 feet of the canal, and partially completed upon the remainder.

2. To continuing the excavation which, with the exception of a few minor details, was completed upon 1,880 feet of the canal.

3. To continuing the construction of the piers on each side of the mouth of the canal to the distance of 450 feet into the lake; these were built by hired labor and purchase in open market. The officer in charge stated that it would require $61,351.50 to complete the work in addition to former appropriations, and gave various reasons for the excess called for over the original estimates.

1837.

An appropriation of $30,000 was made by the act of March 3, 1837. The revetment of the sides of the canal was nearly finished and the excavation was continued, so that by the close of the season 3,387 feet of the canal was completed; the piers were carried out to a depth of 10 feet, the south pier being 597 feet and the north pier 515 feet in length; it was, however, deemed necessary to continue them out to a depth of 12 feet and to construct a beacon on the south pier head.

1838.

An appropriation of $15,000 was made by the act of July 7, 1838. Operations were continued upon the canal prism and the piers; 27,278 cubic yards of earth were excavated from the canal prism and from between the piers in the lake, and about 19,000 yards yet remained to be removed. The north pier was prolonged 60 feet and the south pier 30 feet; it was also found necessary to protect the lake shore on the north side of the canal, where it was rapidly wearing away, by six cribs filled with stone, and to raise the walls of the canal to prevent sand from being washed into the channel.

The officer in charge asked for $54,920 to complete the whole work.

Up to the close of this year the entire appropriations made up to date, amounting to $90,000, had been expended. No further work was done until the year 1844.

1844.

An appropriation of $20,000 was made by the act of June 11, 1844, and the work placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers. An examination of the harbor showed the piers to be in bad condition, and that the lake was making inroads at the angles where the piers joined the shore; materials were collected for making the necessary repairs.

1845.

This year the old piers were thoroughly repaired; 162 linear feet of the old sheet-pile pier was replaced by new crib-work; the north pier was extended 300 linear feet into the lake, and the south pier 90 feet; but the superstructure upon this portion was not completed.

The lake shore at the angles where the piers joined it was protected by a strong crib-work to prevent breaching; repairs were made to the revetment of the United States Canal where Sandy Creek emptied into it. The artificial channel was dredged wherever trouble occurred, 11,684 cubic yards of mud, sand, &c., were removed, and a depth of 9 feet obtained up to a point just below the docks at Monroe. An estimate of $13,303.95 was submitted for completing the unfinished work, prolonging the north pier, and putting in a pier-head.

1852, 1853, 1854.

No appropriations were made nor any work done between the years 1844 and 1852.

By the act of August 30, 1852, $14,000 was appropriated and the money disbursed, in 1853, by a local agent in the repairs of the piers. Capt. Howard Stansbury, of the Topographical Engineers, who assumed charge in 1854, reported that the appropriation had been expended by the agent, before he took charge, in completing 400 feet of the south pier and partially rebuilding 700 feet of the north pier; the latter was left in an unfinished condition, the style of workmanship being rough and defective; he asked for an appropriation of $19,537.77 to put the harbor in order.

No appropriation was made, however, and in 1857 Lieutenant Colonel Graham reported that the works were rapidly deteriorating, and asked for $23,857 to put them in order. No action was taken upon this recommendation, and nothing more was done until 1866.

1866.

In February Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, in accordance with orders from the Chief of Engineers, made a survey of the harbor and submitted a report with an estimate of the cost of its improvement. General Cram made a careful examination of the piers and reported them to be in a dilapidated condition; he recommended that the north pier should be repaired for a length of 665 feet, and the south pier for a length of 180 feet; the heavy ice in the canal and lake prevented any examination as to depth.

Although the revetment of the banks of the canal was decayed and

broken, General Cram did not think it necessary to rebuild it, as the banks had now become quite solid; he estimated that the cost of the work would be $10,423.66.

An appropriation of $31,015.27 was made by act of June 23, 1866, and contracts were made for repairing both piers.

1867, 1868.

Operations were carried on during the winter of 1866–'67 and during the year 1867, and the piers were put in complete order.

A survey of the channel in the spring of 1868 showed a sufficient depth of water for the requirements of the commerce of Monroe. The total expenditure in repairs up to June 30, 1868, was $20,425.

1869, 1870.

In April, 1869, Maj. Walter McFarland, of the Corps of Engineers, was assigned to the charge of this harbor, and in June he recommended that the bar at the entrance should be dredged; contracts for this work were made in August.

During the year 38,000 cubic yards of sand were removed from the channel and a depth of 12 feet obtained over the bar and through the United States Canal into the river. The shore of the lake at the inner end of the north pier was protected by a revetment to prevent the waters of the lake from breaking through into the canal.

1871.

In April, 1871, Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers. An elaborate survey of the harbor was made in September, and Colonel Gillespie presented a plan for obtaining a depth of 11 feet up to the docks at Monroe at a cost of $15,600.

1872.

An appropriation of $10,000 was made by the act of June 10, 1872, and in August the work of dredging was commenced; thirty-one thousand and twenty-nine cubic yards of mud, &c., were removed and a depth of 11 feet obtained, except in the vicinity of the docks at Monroe, where rock was found; at Cooley's Bar stiff clay was encountered.

1873.

Colonel Gillespie was relieved by Major and Brevet Lieutenant-Colonel Harwood in April, 1873. An appropriation of $15,000 was made by the act of March 3, 1873. The piers were put in complete order and the renewal of the canal revetment was commenced. Colonel Harwood asked for $50,000 for completing the revetment.

1874.

An appropriation of $10,000 was made by the act of June 23, 1874. Operations were continued upon the canal revetment and 2,710 linear feet of it was rebuilt. Colonel Harwood was relieved in June, 1874, by Lieutenant-Colonel and Brevet Colonel Blunt, of the Corps of Engineers.

1875.

An appropriation of $10,000 was made by the act of March 3, 1875. During this year work was continued renewing the canal revetment and a channel was dredged through the outer bar; 1,669 linear feet of revetment was renewed and 18,576 cubic yards of sand removed from the channel at the entrance to the piers.

1876.

An appropriation of $5,000 was made by the act of August 14, 1876. Lieutenant-Colonel and Brevet Brigadier-General Michler relieved Colonel Blunt of the charge of the harbor in December, 1876.

1877.

Operations were continued during this season renewing the canal revetment and 1,905 linear feet were rebuilt. Some minor repairs were made to the piers.

1878.

An appropriation of $2,500 was made by the act of June 18, 1878. The work of repairing the canal revetment was commenced in the fall, but suspended on account of the weather before much was accomplished.

A survey of the channel was made between the lake and the docks at Monroe, which showed that it had shoaled very much and that a depth of 8 feet could not be carried up to the docks. General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers, in December, 1878.

1879.

Operations were commenced in March, 1879, and by June both piers had been repaired and 612 linear feet of the canal revetment renewed. An appropriation of $2,000 was made by the act of March 3, 1879, but did not become available until August.

It was determined to apply it to dredging and to endeavor to make a clear channel 100 feet wide and 9½ feet deep up to the docks at Monroe; a contract was made at 11 cents per cubic yard and the work carried on in August and September; in the progress of operations 12,370 cubic yards of mud, sand, &c., 33 logs, 3 snags, and 10 stumps were removed; a depth of 11 feet was gained up to the inner end of the piers and of 10 feet from thence up to the upper end of Willow Island, a short distance below the docks at Monroe.

The rock reported by Colonel Gillespie was encountered near the docks, and a depth of 8½ feet water found upon it.

Seven old sunken piles, which were dangerous to navigation, were removed from the channel near the north pier.

At the close of the year 1879 the condition of the harbor was as follows:

Through the outer bar and between the piers there was a depth of from 11 to 14 feet at low-water; the north pier was 1,350 feet long and the south pier 935 feet; at their inner ends the piers are about 100 feet apart, and they run parallel to each other until a point is reached about 500 feet from the commencement of the south pier, when they commence to flare and are 200 feet apart at the outer end of that pier; the depth between the piers begins to decrease as soon as the flaring commences,

being about 14 feet at the end of the parallel portion, 12 feet opposite the outer end of the south pier and 11 feet from thence until deeper water is reached in the lake.

The United States Canal is about 4,000 feet long, 100 feet wide, and presents a depth of from 10 to 12 feet, the shoalest portion being at the upper end where it receives the waters from the river Raisin; the section of the river between the United States Canal and the Monroe City Canal is about 3,000 feet long, with a depth in the channel of from 10 to 19 feet, the deepest part being near the Monroe Canal.

The Monroe City Canal, which was built by the city many years since in order to shorten and straighten the channel, is about 1,300 feet long and 100 feet wide, with a depth of from 13 to 16 feet; from the upper end of this canal to just below the docks at Monroe there is a depth of 10 feet until the rock near the docks is reached, upon which there is only 8½ feet water.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

The appropriation of $2,000, made by the act of March 3, 1879, did not become available until July, and as the season was far advanced, instead of advertising through the newspapers, communications were addressed to the owners of dredges in the vicinity asking at what price per yard they would remove about 13,000 yards of sand, &c., from the channel between the docks at Monroe and the lake; three replies were received, and by authority of the Chief of Engineers a contract was made with Mr. William Richardson, the lowest bidder, at 11 cents per cubic yard.

While work was in progress numerous logs, snags, &c., were encountered, embedded in the bottom of the river, which it was necessary to remove, and by authority of the Chiet of Engineers the contractor was allowed pay while removing them at the rate per hour he earned while engaged in ordinary dredging.

Operations were commenced early in August widening and deepening the channel through the bar just below Willow Island; 5,284 cubic yards of mud, clay, &c., were removed from this bar, and a channel gained over 100 feet wide and 10 feet deep; the dredge was then moved to the bar just above the island, when the same width and depth were gained by removing 4,104 cubic yards of mud, &c.; while work was in progress at these two places the dredge removed 33 logs, 3 snags, and 10 stumps from the bed of the river that were dangerous impediments to navigation.

Early in September the dredge was moved up near the docks at Monroe in order to excavate to a depth of 10 feet within 50 feet of them, but it encountered rock, and after removing 472 yards, the work was found to be impracticable without blasting, and the machine was sent to the bar just outside the piers through which a channel 50 feet wide and 11 feet deep was opened by removing 2,510 yards of sand.

The total dredging done was therefore as follows:

	Cubic yards.
From bar above Willow Island	4,104
From bar below Willow Island	5,284
From near Monroe docks	472
From the outer bar	2,510
Total	12,370

Forty-six logs, snags, &c., were removed from the bottom of the river, and seven old piles, which were dangerous to navigation, were taken out from the channel near the north pier.

An examination of the harbor in May, 1880, showed the piers to be

in only tolerable condition and to need considerable repairs, and that 1,000 linear feet of the revetment of the United States Canal and 1,850 feet of that of the Monroe City Canal was in such a dilapidated condition as to need entire renewal; it seems, however, doubtful whether it is necessary to renew the old work in the Monroe Canal, as it is not affected by the heavy sea from the lake; the banks seem to be as solid, and the channel maintains its depth there even better than in other parts of the river.

It is proposed to expend the funds now available in repairing the piers and in continuing work renewing the revetment of the United States Canal.

Up to the close of the present fiscal year the sum of $211,515.27 has been appropriated for this harbor, of which $209,515.27 has been expended.

To complete the repairs of the piers and revetment of the United States Canal, in addition to the funds now available the following will be necessary:

Repairs of piers	$1,000 00
Renewing 700 feet of revetment of the United States Canal, at $2.50 per foot	1,750 00
Contingencies	250 00
Total	3,000 00

It will probably be necessary to renew the superstructure of the piers in the course of the next two or three years, and in the meantime an annual appropriation of $1,000 will be required to keep them in order.

Three thousand dollars can be profitably expended upon this work during the next fiscal year.

Judging from the report of the collector of customs, the amount of commerce to be benefited by the completion of this work is very small.

RÉSUMÉ.

It will be observed by the foregoing history that the improvement of this harbor was commenced fifty-three years ago, at La Plaisance Bay, abandoned there in 1835, and begun in that year upon the present project.

The River Raisin at that time was an important commercial point, and a channel was obtained through a sandy peninsula and up to the docks at Monroe for all vessels then navigating the lakes.

The policy of the general government in regard to internal improvements was changed four years after the work was commenced, and with the exception of appropriations in 1844 and 1852, which were devoted to repairs and dredging, no further funds were available until the year 1866. Since that time operations have been confined to renewing the old works, extending the piers and dredging, and at this time there is a depth in the channel of not less than 10 feet up to where the rock appears, just below the docks at Monroe, which is quite equal to that which was originally projected and sufficient for the present commerce of the port.

The harbor of Monroe is in the collection district of Detroit, Mich.: there is a fixed white light of the fourth order on the outer end of the west pier. The nearest work of defense is Fort Wayne, which is 30 miles distant.

The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $25.95; 24 vessels, with an aggregate tonnage of 1,909 tons, cleared during this period, and 29 vessels, with an aggregate tonnage of 2,030 tons, entered.

Abstracts of proposals and contract and a money statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$2,011 44	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$4,011 44
July 1, 1880, amount expended during fiscal year		2,011 44
July 1, 1880, amount available		2,000 00
Amount (estimated) required for completion of existing project		3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		3,000 00

Abstract of bids by circular letter for improvement of Monroe Harbor, Mich., received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, under authority of the Chief of Engineers, U. S. A., dated July 24, 1879.

Number.	Name and address of bidder.	For dredging from 10,000 to 14,000 cubic yards of material and dumping same not farther than 1½ miles.	For dredging from 10,000 to 14,000 cubic yards of material and dumping same not farther than 3 miles.	For dredging from 10,000 to 14,000 cubic yards of material and dumping same not farther than 4 miles.
		Per cub. yd.	*Per cub. yd.*	*Per cub. yd.*
1	William Richardson, Buffalo, N. Y.*	$0 10	$0 11	$0 11
2	E. H. French, Toledo, Ohio	15	18	20
3	James Rooney, Toledo, Ohio	30	30	30
4	O. J. Jennings, Dunkirk, N. Y.	13½	15	16½

*Contract awarded; lowest bidder; approved by the Chief of Engineers.

Abstract of contract for improving harbor at Monroe, Mich., in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Date of contract.	Subject of contract.	Mud, clay, sand, &c., per cubic yard, in scows.
Wm. Richardson, Buffalo, Erie County, New York*	Aug. 2, 1879	Dredging	$0 11

*Contract completed and closed September 23, 1879.

I I 2.

IMPROVEMENT OF TOLEDO HARBOR, OHIO.

HISTORY OF THE WORK.

The city of Toledo, Ohio, is situated at the mouth of the Maumee River; the Maumee River empties into Maumee Bay at a point, by way of the channel, about 7 miles from the deep water of Lake Erie.

The attention of the general government was first called to this harbor by the act of June 23, 1866, wherein an appropriation of $20,000 was made for its improvement.

Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, was assigned to the charge of the work, and after a careful examination submitted a report in August, 1866. He stated that the channel in Maumee River was in good condition, but that after entering the bay, for a distance of about 1 mile, there was a depth of only about 11 feet in the channel with a width too narrow for vessels to navigate without grounding on the adjacent shoals.

General Cram recommended that the channel be widened to 200 feet and deepened to 12 feet, and estimated the cost of the work at $10,650; he intimated that continual dredging would be required from time to time.

Proposals were invited for dredging upon what is now known as the Phenstock Range, and a contract was made in October for the work, but stormy weather prevented operations during the remainder of the year.

1867.

An appropriation of $20,000 for continuing the work was made by the act of March 3, 1867. Operations were commenced on the Phenstock Range March 27, and were continued until November 30, when they were suspended on account of the weather; 44,571 cubic yards of mud, sand, &c., were removed at a cost of 45 cents per cubic yard.

1868.

Work was resumed March 30, and continued until the close of the season; 37,598 cubic yards of mud and sand were removed during the year.

Operations during 1867 and 1868 were continued on about the same range and over a distance of about 1⅛ miles in the most troublesome part of the channel; a depth of 12 feet at low-water, with a width of 170 feet, was obtained.

On December 27, General Cram submittted to the Chief of Engineers a project for opening a straight ship canal on the prolongation of the Maumee River, with a depth of 13 feet at low-water, to the 13-foot curve in the lake, at an estimated cost of $885,526.

1869.

General Cram's plan was submitted to a Board of Engineers, which convened in January, 1869; it was rejected on account of bad location, defective method of construction, and excessive cost; in its place the Board recommended that the present channel should be dredged throughout its entire length for a width of 200 feet and a depth of 12 feet, at an estimated cost of $152,800.

General Cram was relieved by Maj. W. McFarland, of the Corps of Engineers, in April, 1869, and early in June a careful survey was made of the channel through Maumee Bay. An allotment of $29,700 was made from the general appropriation for rivers and harbors, and a contract was executed for continuing the dredging in the natural channel at 35 cents per cubic yard.

In June, 1869, the collector of the port reported that, on account of the bar at the mouth of the river, "at present no vessel can enter this harbor, at the ordinary stage of water, which draws more than 9 feet."

Work was commenced in August, 1869, with three dredges, and by the close of the year 27,089 cubic yards of mud and sand had been removed, and a channel 3,080 feet long, 50 feet wide, and 12 feet deep completed.

1870.

Operations were resumed in May, dredging in the natural channel, and were continued until November. During this season 46,564 cubic yards of mud and sand were removed from the channel.

An appropriation of $50,000 was made by the act of July 11, 1870, for the further improvement of the harbor.

1871.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, April 25, 1871.

An appropriation of $50,000 was made by the act of March 3, 1871.

In February a contract was made for continuing the dredging at 21 cents per cubic yard, with an allowance of $25 per day for demurrage when the dredges were idle from stress of weather.

After the appropriation of March 3 was available, proposals were invited for work under that, and a contract was made at 30 cents per cubic yard.

Operations were continued throughout the year in the natural channel between the mouth of the river and Turtle Island; 284,890 cubic yards of mud and sand were removed, and a channel 120 feet wide and 14 feet deep was reported completed out to the end of the "Black Can Range."

1872.

An appropriation of $15,000 was made by the act of June 10, 1872. Operations were resumed early in the spring under the last contract, and by the end of June 47,901 cubic yards of mud and sand had been removed.

A new contract, under the appropriation of June 10, was made at 29 cents per cubic yard, and work resumed in September; 43,000 cubic yards of mud, sand, &c., were excavated under the last contract, making a total of 90,901 cubic yards removed during the season.

By direction of the Chief of Engineers a Board of Engineers convened at Toledo in December, 1872, to continue the subject of the channel through Maumee Bay. The Board submitted three plans, as follows:

1st. A straight cut through North Cape Point, at an estimated cost of $1,853,500.

2d. To extend the Maumee River through the bay and North Cape to Lake Erie, confining the river water in a new channel of about the same dimensions as its natural bed, at an estimated cost of $3,074,500. This second plan was deemed by the Board the most complete solution of the problem before it, the result of which could be predicted with the most certainty.

3d. To improve the existing natural channel through Maumee Bay, by widening it to 250 feet at the surface and 200 feet at the bottom with a depth of 15 feet; the estimated cost of this plan was $450,000.

The Board recommended the third plan, being influenced in its favor by the urgent necessity that existed that the improvement should be made in the shortest possible time, and the fact that either of the other plans would involve a delay of many years, even with large annual appropriations.

The third plan was approved by the Secretary of War, and work has continued upon it since 1873.

1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873.

An appropriation of $100,000 was made by the act of March 3, 1873, and a contract made for the use of four dredges, with tugs, scows, &c., at $115 per day of ten hours when working, and $10 per day when idle from stress of weather.

Work was commenced early in July and continued throughout the season with four machines, the depth of 15 feet having been gained in the portion of the natural channel where operations were in progress; about 120,000 cubic yards of mud, sand, &c., were removed.

1874.

Operations were resumed early in the season, with four dredges, under the last contract of 1873, and by the end of the fiscal year a channel about 80 feet wide and 15 feet deep was reported as completed.

An appropriation of $75,000 was made by the act of June 23, 1874. In August a contract was made for four dredges with tugs, &c., at $350 per day of ten hours while working, and $20 per day when idle from stress of weather; work was resumed August 17 and continued until the close of the season in November, widening and deepening the channel through the bay; about 375,000 cubic yards of mud, sand, &c., were removed during the year.

Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers, June 30, 1874.

1875.

An appropriation of $75,000 was made by the act of March 3, 1875. In April a large filling was found to have taken place at the angle connecting the Can and Phenstock ranges, and work was at once resumed removing the deposit; four dredges were employed during the month of May; on May 22, a contract was made for six dredges; with tugs, scows, &c., at $100 per day of ten hours each, and $20 per day, each, when idle from stress of weather; work was continued in the north and southwest reaches of the channel until the last of October, when it was suspended for the season; 368,589 cubic yards of mud, sand, &c., were removed from the channel during the year.

Colonel Blunt stated in his annual report that it would require $140,000 to complete the channel as planned, and that after it was finished small annual appropriations would be required to remove the deposits which would naturally be made.

1876.

An appropriation of $60,000 was made by the act of August 14, 1876. This money became available to the engineer in charge about the middle of September, too late for operations during the season.

Colonel Blunt was relieved by Lieut. Col. and Bvt. Brig. Gen. N. Michler, of the Corps of Engineers, in December, 1876.

1877.

Operations were commenced April 30, with two dredges, excavating at the rate of 12½ cents per cubic yard, and in June three more dredges were placed at work, excavating at the rate of 14 cents per cubic yard.

Operations were continued during the year on the outer reach of the

channel beyond Turtle Island, and on the reach running south from that island; 282,730 cubic yards of sand were removed from the channel during the year. No appropriation was made during the year.

1878.

Operations were resumed early in the spring and were continued until May 29, when they were suspended for want of funds; 62,628 cubic yards of mud and sand were removed from the Middle and Manhattan ranges, and from the elbow connecting them, and from the elbow connecting the Phenstock and Can ranges. An appropriation of $50,000 was made by the act of June 18, 1878, and in September a contract was made for removing 200,000 cubic yards of mud, sand, &c., at 9¾ cents per cubic yard.

Work was resumed in September and was confined to the Phenstock range, to the elbows at each end of it, and to the reach running north and south, west of Turtle Island. Operations were suspended for the season November 30; 194,235 cubic yards were removed under this last contract, making a total of 256,863 cubic yards removed during the year.

General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers, December 16, 1878.

1879.

Operations were resumed with five dredges early in April in the south reach, west of Turtle Island, and by April 12 the contract of September, 1878, was completed. A new one was at once executed, at 9¾ cents per cubic yard. Operations were continued until July 1 on the south reach, running north and south, west of Turtle Island, and a channel 200 feet wide at bottom and 250 feet wide at top was obtained in this reach, with a depth of 15 feet, except at a few minor points, by removing 181,297 cubic yards of sand, &c.

On July 1 the dredges were removed to the extreme outer range in the lake, beyond Turtle Island, and continued work there until August 4. During this period this section of the channel, 3,000 feet long, was windened to 200 feet at the bottom, 250 feet at top, and a full depth of 15 feet obtained. Operations were suspended for the season August 5, 236,246 cubic yards of sand, &c., having been removed from the channel.

An appropriation of $20,000 was made by the act of March 3, 1879, but did not become available to the engineer in charge early enough to prepare for further work during the season. In December proposals were invited for excavating 100,000 cubic yards of mud, sand, &c., from the channel.

In August, 1879, a survey was made of the channel with the following results:

From the 15-foot curve in the lake to the inner end of the south or Turtle Island reach, there was a channel 200 feet wide at bottom and not less than 15 feet deep; on the Can range there was a channel similar in width, with a depth of from 14 to 16 feet. At the elbow connecting the Can and Phenstock ranges there was considerable filling and a depth of only from 12 to 14 feet. On the Phenstock range, with a similar width, the depth varied from 13½ to 15½ feet. On the Middle range, with a similar width, the depth varied from 14½ to 16 feet; and on the Manhattan range the least depth was 15 feet. Not less than 15 feet was found in the channel from thence to the docks at Toledo.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

The opening of the fiscal year found operations in progress under the contract of April 1 with Mr. E. H. French, dredging the channel between Toledo and the lake. On July 1 five dredges were placed at work upon the extreme outer or lake range of the channel, and were continued there until August 4. During this period a depth of 15 feet was gained in a channel 200 feet wide and 3,000 feet long, out to the curve of 15 feet in the lake, by removing 45,878 cubic yards of sand. The outer range being completed, the dredges were placed on the Can range, from which 2,775 cubic yards of sand were removed. The contract having been completed, the work of dredging was suspended. A complete survey of the channel was made in August, the result of which is found in another portion of this report.

In December proposals were invited for continuing the work, and in January a contract was made for removing 100,000 cubic yards of sand, mud, clay, &c., at 14 cents per cubic yard.

Work was commenced the latter part of April, and by May 3 three dredges were at work upon the Phenstock range and at the angle of the Can and Phenstock ranges where the greatest filling had occurred. As there is more or less sedimentary deposit constantly going on, it was deemed best to dredge to 16 feet in order to maintain the full depth of 15 feet for some time. Work was continued until the close of the fiscal year, and 77,995½ cubic yards of mud, &c., were removed under this contract, making a total of 126,649 cubic yards removed during the year.

The work under the present project for a depth of 15 feet is rapidly drawing to a completion; the original estimate for this plan was $450,000; of this amount $400,000 has been appropriated up to the close of the present fiscal year. For completing this project, for widening the channel at the angles, removing deposits from the inner and outer reaches, &c., the sum of $20,000 is asked for the next fiscal year.

But Toledo now asks for deeper water, and I must earnestly recommend that the demands of her growing commerce may be complied with, and that she may be granted the full depth of 16 feet which is now carried through the Saint Clair Flats Canal and will soon be available between Lake Superior and Lake Erie. The amount to be removed to obtain this depth, in addition to that required to complete the present project, will be about 500,000 cubic yards, and as the cutting is light, I estimate that it will cost about 20 cents per yard, or $100,000.

I most earnestly recommend that this great and much to be desired improvement may be pushed forward as rapidly as possible; at least $100,000 could be profitably expended during the next fiscal year.

The following data, taken from the very able and interesting report of Mr. D. B. Smith for the year ending December 31, 1879, to the Toledo Produce Exchange, shows the extraordinary growth of the trade of Toledo:

Annual receipts of flour, wheat, &c., at Toledo, Ohio.

Year.	Flour.	Wheat.	Corn.	Oats.
	Barrels.	*Bushels.*	*Bushels.*	*Bushels.*
1876	536,158	9,016,068	16,334,291	3,418,601
1877	556,335	8,151,712	17,589,558	2,540,760
1878	751,212	17,497,748	19,265,752	3,699,877
1879	801,931	22,501,616	16,133,728	4,046,073

A glance at this table will show that in four years, or since the channel has been made available for vessels of deeper draught, the receipts of flour have increased 50 per cent., of wheat 150 per cent., and of oats nearly 20 per cent.; of the wheat received, 40 per cent. was sent away via the lake in 1876 and 1877, and about 60 per cent. in 1878 and 1879.

In addition to the enormous trade in grain, large amounts of lumber, coal, iron, salt, &c., are annually handled.

In my last annual report I stated that I believed, in order to make the channel between Toledo and the lake permanent, it would be necessary to revet it for 6 or 7 miles. Since that time I have made a careful study of the subject and have prepared an estimate of the cost; I have determined now not to recommend this revetment.

The estimate of the cost of this work is as follows:

17,394 feet of pile revetment on Manhattan range, at $8.50	$147,849 00
15,425 feet of pile revetment on Middle and Pheustock ranges, at $8.50	131,112 50
11,487 feet of pile revetment on northwest side of Can range, at $8.50	97,639 50
11,815 feet of pile pier on southeast side of Can range, at $18	212,670 00
15,590 feet of pile pier on Turtle Island range, at $18	280,620 00
2,300 feet of cribwork beyond Turtle Island, at $60	138,000 00
Outer pier-head	2,950 00
Total	1,010,841 00

If this should be built, we would have about 14 miles of pier and revetment, which would constantly require repairs, and I am satisfied that with an annual expenditure of from 1 to 2 per cent. of this estimate, the channel when once completed can be easily kept open.

During the fiscal year 1880-'81, it is proposed to continue dredging the natural channel through Maumee Bay to the width proposed by the Board of Engineers, and in order to maintain the depth of 15 feet required by that project the material will be excavated to a depth of 16 feet.

I again most urgently but respectfully call the attention of the Light-House Board to the great necessity for more day beacons and range-lights to mark the channel through Maumee Bay; there should be beacons to mark every range; the cost would be comparatively trifling, and I cannot too strongly urge that immediate attention be given to this subject, which is of the very utmost importance to the rapidly increasing commerce of Toledo.

The total amount appropriated for this harbor up to the close of the present fiscal year is $594,700, of which amount $557,842.19 has been expended.

RÉSUMÉ.

It will be observed by the foregoing history that this work of improvement was commenced in 1866. At that time the channel through the bay was very narrow and the depth only 11 feet; by 1868 a channel 150 feet wide and 12 feet deep was completed; by 1875 the depth had increased to 14 feet with a width of 100 feet; by 1879, to a width of 200 feet with a depth of from 13 to 16 feet; and at the close of the fiscal year ending June 30, 1880, there was a channel from 200 to 250 feet wide with a depth of from 14 to 16 feet from the lake to the docks at Toledo, and it was anticipated that by the close of the season of 1880 the full depth of 15 feet would be obtained throughout the channel.

Toledo is in the collection district of Miami. There is a fixed white light of the 4th order on Turtle Island, and three sets of range-lights for parts of the channel. The nearest work of defense is Fort Wayne, 45 miles distant.

The amount of commerce to be benefited by the improvement is large and con-

stantly increasing. The amount of revenue collected during the 11 months from July 1, 1879, to May 31, 1880, was $26,723.19. The value of the imports during this period was $84,575.24, and of the exports $4,199,154. The number of vessels entering during this period was 2,290, with an aggregate tonnage of 697,281 tons, and clearing 2,289, with an aggregate tonnage of 700,471 tons.

Abstracts of proposals and contracts and a money statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$27,677 88	
Amount appropriated by act approved June 14, 1880	30,000 00	
		$57,677 88
July 1, 1880, amount expended during fiscal year	19,728 15	
July 1, 1880, outstanding liabilities	1,091 92	
		20,820 07
July 1, 1880, amount available		36,857 81
Amount (estimated) required for completion of existing project		120,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		100,000 00

Abstract of proposals for dredging 100,000 cubic yards, more or less, of mud, clay, sand, &c., from the channel through Maumee Bay, Toledo Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, January 27, 1880, under advertisement of December 17, 1879.

Number.	Name of bidder.	Address of bidder.	Rate per cubic yard.	Remarks.
1	J. C. & J. H. Davis	Toledo, Ohio	$0 14¾	
2	Jesse Sims and Patrick Smith.	Cleveland, Ohio	20	
3	E. H. French	Fulton, Oswego County, New York.	14	Contract awarded subject to the approval of the Chief of Engineers.
4	H. T. Stock	Toledo, Ohio	14½	

Abstract of contracts for improving harbor at Toledo, Ohio, in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Dates of contracts.	Subject of contract.	Mud, sand, clay, &c., per cubic yard, in scows.
Edwin H. French, Fulton, Oswego County, New York*	April 1, 1879	Dredging	$0 09¾
Do	Feb. 9, 1880	do	14

*Contract completed and closed August 6, 1879.

I I 3.

IMPROVEMENT OF PORT CLINTON HARBOR, OHIO.

HISTORY OF THE WORK.

Port Clinton, Ohio, is situated at the mouth of the Portage River, a stream which, rising in the northwestern part of Ohio, flows first in a northeasterly and then in an easterly direction and empties into Lake

Erie. For miles above its mouth and bordering upon its banks are extensive tracts of superior hardwood timber, from which lumber, staves, axe-handles, hubs, spokes, &c. are sent to Port Clinton for shipment.

The attention of the general government was first called to this locality by the act of Congress approved March 2, 1867, wherein a survey was ordered upon which to base a plan of improvement.

This survey was made by Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, who submitted a project for improving the harbor at an estimated cost of $80,000. No action was taken upon this report, and by the act of July 11, 1870, another survey was ordered.

1870, 1871.

In the fall of 1870, the survey ordered by the act of July 11, 1870, was made by Maj. W. McFarland, of the Corps of Engineers. He reported that there was a narrow channel at the entrance to the river, with a depth of from 5 to 6 feet. He submitted a plan for cutting a channel 8 feet deep through the outer bar, and for constructing east and west piers, extending from the shore lakeward to the necessary depth, to confine the waters of the Portage River to the new opening. This plan required the construction of 4,500 feet of pier, and the estimated cost of the work was $120,000.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, in April, 1871.

1872, 1873, 1874.

The first appropriation, of $8,000, was made by the act of June 10, 1872. This sum, with an additional amount of $2,000 allotted from the appropriation for examinations and surveys, was expended in opening a cut 20 feet wide and 8 feet deep from the river into the lake by removing 20,302 cubic yards of sand, and in constructing a sand fence 550 feet long along the peninsula north of the mouth of the river, to prevent the sand from drifting into the channel.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873, and in the annual report of the latter for that year he stated that unless piers were built, and the waters of the river directed across the bar, it would be impossible to maintain a channel with a depth of 8 feet.

Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers, June 30, 1874.

1875.

An appropriation of $5,000 was made by the act of March 3, 1875, and an examination of the harbor showed that the channel dredged in 1872-'73 had entirely filled up, as had been expected.

Colonel Blunt made a report in March, 1875, in which he suggested the construction of a pile dike running from the end of the sand fence, constructed in 1874, out into the lake; he also recommended a change in the location of the piers, as previously projected; he proposed to run a pile revetment from the end of the sand fence about 1,000 feet out into the lake in a direction north 57 degrees east, and then inclining towards the north; to extend a cribwork about 1,200 feet to the 10-foot curve in the lake. Parallel to this, at a proper distance (afterwards fixed at 200 feet), he proposed to build an east pier, about 2,400 feet long, its inner end

resting on shore; he believed that when the waters of the Portage River were confined between these piers a depth of 9 feet could be maintained.

This revised plan was approved, the estimated cost being $122,000. Operations were commenced on the pile work in April, 1875, and by the close of the fiscal year, June 30, 840 linear feet had been completed. The shore line on the north side of the peninsula at once began to move out, and the current at the mouth of the river was no longer overcome by the lake littoral current from the westward.

1876.

An appropriation of $5,000 was made by the act of August 14, 1876. An examination of the harbor shows that the channel had deepened parallel and close to the pile revetment constructed in 1875. No work was done in 1876, the appropriation not being made available during the year.

Colonel Blunt was relieved by Lieut. Col. and Bvt. Brig. Gen. N. Michler, Corps of Engineers, in December, 1876.

1877.

Work was commenced in May upon the pile revetment on the east side of the proposed channel, and 590 linear feet of it was constructed; a gap 150 feet wide was left on the line of the old channel for the accomodation of vessels.

1878.

An appropriation of $10,000 was made by the act of June 18, 1878, and was devoted to extending the revetments and dredging the channel. Operations were commenced early in July, and continued until the last of September. The west revetment was prolonged 300 feet, the east revetment 205 feet, and the gap of 150 feet left in the work in 1877 was closed. A new channel 2,000 feet long, 60 feet wide, and 10 feet deep was excavated from the mouth of the river to the 10-foot curve in the lake by removing 19,487 cubic yards of clay, mud, and sand.

General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers, December 16, 1878.

1879.

An appropriation of $10,000 was made by the act of March 3, 1879, but was not available to the engineer in charge until August.

Proposals were invited in August for constructing 300 linear feet of pile pier on the prolongation of the west revetment, and for extending the east revetment 600 feet; contracts were made in September, 1879, for this work, but the season was too far advanced to commence operations this year.

The winter gales of 1878–'79 had completely closed the channel dredged in 1878, beyond the piers, so that there was a depth of less than 4 feet on the outer bar; for the convenience of commerce an opening of 50 feet was made on the line of the old channel, through the east revetment, and this will be left open until the project for the harbor is nearly completed.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

Operations were commenced upon the prolongation of the piers in April, 1880, under the contract of September, 1879, and by the close of

the fiscal year the pile work was completed upon 300 feet of the west pier and 320 feet of the east revetment.

The benefit of the prolongation of the piers was at once made evident by the deepening of the channel.

During the present season it is proposed to extend the west pier 300 feet and the east pier 600 feet, under the present contract, and with the funds appropriated by the act of June 14, 1880, to further prolong the former 100 feet and the latter 250 feet.

The estimated cost of the present project was $120,000; since work was commenced under it, the following appropriations have been made:

Act of March 3, 1875	$5,000
Act of August 14, 1876	5,000
Act of June 18, 1878	10,000
Act of March 3, 1879	10,000
Act of June 14, 1880	5,000
Total	35,000

Of this amount, $21,172.45 has been expended up to June 30, 1880.

After the completion of the work proposed under the funds now available, there will yet remain to be built 400 feet of pile pier and 500 feet of pile revetment, and a channel 150 feet wide and 10 feet deep should be dredged for a length of 2,000 feet between the piers.

The estimated cost of this work is $50,000. Twenty thousand dollars can be profitably expended during the next fiscal year, and if appropriated will be applied to extending the piers.

Port Clinton is a port of entry in the collection district of Sandusky, Ohio. The nearest work of defense is at Fort Wayne, 60 miles distant; the nearest light-house is at Green Island, 10 miles distant.

I have no means of estimating the amount of commerce which will be benefited by the completion of this work.

The amount of revenue collected during the first eleven months of the present fiscal year was $37. Thirty-one vessels, with an aggregate tonnage of 2,523 tons, entered, and 40 vessels, with an aggregate tonnage of 2,977 tons, cleared during the same period.

Abstracts of proposals and contracts and a money statement are transmitted herewith

Money statement.

July 1, 1879, amount available	$10,200 50	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$15,200 50
July 1, 1880, amount expended during fiscal year		1,372 95
July 1, 1880, amount available		13,827 55
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

Abstract of proposals for prolonging the piers at Port Clinton Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

Number.	Name and address of bidder.	Approximate quantities.					Totals.
		White-oak or red-elm piles, 18,970 linear feet, more or less, per linear foot, including driving.	White-oak timber and plank, 73,099 feet b. m., more or less, per M. feet b. m., including sheathing, piles, and their driving.	Brush or mill clippings for fascines and mattresses, 150 cords, more or less.	Stone filling, 130 cords, more or less.	Stone riprap, 150 cords, more or less.	
				Pr cord.	*Per cord.*	*Per cord.*	
1	C. Schulz, Cleveland, Ohio...	$0 29 5, 501 30	$49 00 3, 581 85	$6 00 900 00	$6 88 894 40	$6 88 1, 032 00	$11, 909 55
2	John Stang, Lorain, Lorain County, Ohio.*	18 3, 414 60	21 00 1, 535 07	1 00 150 00	3 00 390 00	3 00 450 00	5, 939 67
3	Hemenway & Hayes, Painesville, Ohio.	22 4, 173 40	25 00 1, 827 47	2 50 375 00	3 50 455 00	3 50 525 00	7, 355 87
4	Thomas Keeler, Fulton, New York.	28 5, 311 60	30 00 2, 192 97	3 00 450 00	5 00 650 00	5 00 750 00	9, 354 57
5	Courtland D. Merry, Somerset, Pulaski County, Kentucky.	25½ 4, 837 35	24 75 1, 809 20	1 85 277 50	4 95 643 50	4 95 742 50	8, 310 05
6	Gustavus A. Karwiese, New York City, New York.	23 4, 363 10	23 40 1, 710 52	3 75 562 50	11 45 1, 488 50	13 50 2, 025 00	10, 149 62
7	Charles Roose, Oak Harbor, Ottawa County, Ohio.	19 3, 604 30	Sheathing plank, $26; oak timber and plank, $24; 31,680 feet, b.m., sheathing plank; 41,419 feet, b. m., oak timber and plank. 1, 817 74	2 25 337 50	3 70 481 00	3 70 555 00	6, 795 54
8	Hammond & Ellis, Elliston, Ottawa County, Ohio.	26 4, 932 20	24 00 1, 754 38	5 00 750 00	3 25 422 50	3 25 487 50	8, 346 58
9	Alph'se Couche, Port Clinton, Ohio.	18 3, 414 60	28 00 2, 046 77	2 00 300 00	3 75 487 50	3 75 562 50	6, 811 37

* Contract awarded subject to the approval of the Chief of Engineers.

Abstract of proposals for prolonging the piers at Port Clinton Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Rods, 3,600 pounds, more or less, per pound.	Screw bolts, 5,300 pounds, more or less, per pound.	Drift bolts, 65,300 pounds, more or less, per pound.
1	Charles Roose, Oak Harbor, Ottawa County, Ohio*	$0 05 180 00	$0 05 265 00	$0 04½ 13 50
2	Samuel A. Sague, Cleveland, Ohio	4 144 00	4¼ 225 25	3⅛ 10 12
3	Cleveland, Brown & Co., Cleveland Ohio†	3.34 120 24	4.34 230 02	3.39 10 17

Number.	Name and address of bidder.	Wrought spikes, 2,450 pounds, more or less, per pound.	Totals.
1	Charles Roose, Oak Harbor, Ottawa County, Ohio*	$0 04½ 110 25	$568 75
2	Samuel A. Sague, Cleveland, Ohio	1,030 pounds 12″ and 10″ spikes, at 3¼ cts. $33 47 500 pounds 9″ spikes, at 3½ cents .... 17 50 920 pounds 7″ and 8″ spikes, at 3⅝ cts. 33 35 2,450 pounds 84 32	463 00
3	Cleveland, Brown & Co., Cleveland, Ohio†	$0 03.94 96 53	456 96

*Bid thrown out; not made in accordance with the specification, it being made out in the bill for workmanship, and all other materials except iron.

†Contract awarded subject to the approval of the Chief of Engineers.

Abstract of contracts for improving harbor at Port Clinton, Ohio, in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Dates of contracts.	Subject of contract.	White-oak or red-elm piles, per linear foot, including driving.	White-oak timber and plank, including sheathing plank and their driving, per M feet, board measure.	Brush or mill clippings, per cord.	Stone filling, per cord.	Stone riprap, per cord.	Rods, per pound.	Screw and washer-bolts, per pound.	Drift bolts, per pound.	Wrought spikes, per pound.
	1879.							Cts.	Cts.	Cts.	Cts.
Cleveland, Brown & Co., Cleveland, Cuyahoga County, Ohio*	Sept. 25	(†)	....	....	....	....	......	3.34	4.34	3.39	3.94
John Stang, Lorain, Lorain County, Ohio	Sept. 27	(‡)	$0 18	$21 00	$1 00	$3 00	$3 00	......	......	......	......

*Contract completed and closed May 10, 1880. †Iron rods, &c. ‡Material and workmanship.

I I 4.

IMPROVEMENT OF SANDUSKY HARBOR, OHIO.

HISTORY OF THE WORK.

The attention of the general government was first called to this harbor by the act of May 20, 1826, by which an appropriation of $400 was made "to ascertain the expediency and expense of constructing piers to improve the navigation thereof, and of placing buoys therein." A survey was made by Lieut. C. Graham, of the Third Artillery, then on duty with the Corps of Topographical Engineers, and a report was submitted, but Congress took no action thereon.

Sandusky Bay was described as a beautiful sheet of water, emptying into Lake Erie about 40 miles from its western extremity; it was a natural harbor containing an area of about 22½ miles, protected on the north and northwest from the gales of the lake by a long narrow peninsula, commencing just above the mouth of Sandusky River and extending eastwardly for about 10 miles, and on the southeast by what is known as Cedar Point.

About 1 mile outside of Cedar Point was a bar upon which there was a depth of only 10 feet, but after crossing it a wide channel was found off the point, increasing in depth to 36 feet and then gradually shoaling to about 11½ feet after getting inside the bay. The greatest depth in the bay, and which was found over quite a large area, was 12 feet. It will thus be seen that at this early period only 10 feet water was found at the entrance to this harbor.

1844, 1845.

The first appropriation for this harbor was one of $15,000, made by the act of June 11, 1844, and the work was placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers.

A new survey was made in June, 1844, which showed that while the channel had shifted somewhat, there was still a depth of 10 feet at the entrance, but vessels after crossing the outer bar could carry 11½ feet up to the town of Sandusky. The outer 2 miles of the main peninsula was now separated from it by a channel 1,520 feet wide, with a depth of 6½ feet, through which the water passed with great velocity, and in this section of 2 miles there were three breaches, aggregating about 650 feet in width.

It was determined to apply the appropriation towards closing the main breach in the peninsula; for this purpose a crib-work 6 feet wide was commenced on each side of the breach, resting on the sand and narrowing the opening by degrees; 736 feet of this crib-work was built on the east side and 612 feet on the west side; timber for completing the work was purchased, but the appropriation was exhausted before the breach was closed. No further appropriation was made until 1852.

In the annual report for 1845, $11,378.67 was asked for, to close the breach, and piles were recommended over the outer bar.

1848.

A survey made this year showed that while the channel had shifted, about the same depth was maintained as was found in 1844.

1852, 1853, 1854, 1855, 1856.

An appropriation of $15,000 was made by the act of August 30, and the work was placed in charge of Capt. H. Stansbury, of the Corps of Topographical Engineers.

An examination of the harbor showed about the same depth as was found in 1848, but Peninsula Point was being rapidly washed away, the northern gales having made several breaches and greatly reduced its area.

The appropriation of August 30, 1852, was devoted during the year 1853 and 1854 to constructing along the line of the peninsula for its protection a rough crib-work 3,357 feet long. Captain Stansbury stated in his annual report in September, 1855, that this crib-work was answering its purpose admirably, and that the peninsula had increased in width and height; he asked for the sum of $112,117 for closing the breach between the "peninsula and main shore," and for completing the crib-work protection along the entire outer portion of the peninsula; this recommendation was repeated in his annual report for 1856.

1857, 1858, 1859.

Maj. and Bvt. Lieut. Col. J. D. Graham, of the Corps of Topographical Engineers, assumed charge of the harbor in 1857, and repeated the recommendation of Captain Stansbury. No action was taken upon these recommendations, and during the winter of 1859 the crib-work was nearly all destroyed.

1862.

A new survey of the harbor was made under the direction of Col. J. D. Graham in 1862; the outer bar maintained about the same distance from Cedar Point, but a narrow channel had worked through to the northwest with a depth of 13 feet while there was a depth of 12 feet on the bar inside of Cedar Point; there was considerable change in the shape and depth of the channel near Cedar Point; it is possible that the soundings during this survey were not referred to the same zero as those previously made, and this may account for the increased depth shown on the chart.

1864.

In October 1864, Col. T. J. Cram, lieutenant-colonel Corps of Engineers, submitted a report in which he recommended the dredging of the outer bar so as to get a straight channel 400 feet wide and 12 feet deep, and the construction, if found necessary, of parallel piers, 400 feet long, to maintain the channel; the estimated cost of the work was $38,580.

The channel through the outer bar at this time presented a depth of about 10 feet.

1866.

An appropriation of $38,580 was made by the act of June 23, 1866, and General Cram recommended that it should be applied to dredging a channel 400 feet wide and 12 feet deep through the outer bar. A contract was made for this work in October, 1866, at the rate of 75 cents per cubic yard.

1867, 1868.

Operations were commenced in June, 1867, and continued under the contract of October, 1866, through the seasons of 1867 and 1868, during

which time 24,317 cubic yards of sand were removed from the channel through the outer bar.

1869.

General Cram was relieved in April, 1869, by Maj. W. McFarland, of the Corps of Engineers.

The channel through the outer bar was examined in June and found to be 240 feet wide with a depth of 12 feet, except at two localities where, for a short distance, it was only 11½ feet deep. As the depth on the outer bar was greater than on the inner one, Major McFarland recommended that the remainder of the appropriation should be applied to deepening the channel through the inner bar, and a contract was made in August for this purpose at 33¼ cents per cubic yard. The heavy gales in the fall of 1869 prevented work during the year.

1870.

Operations were commenced in July and continued until the close of November, and a channel 2,500 feet long, 60 feet wide, and 12 feet deep was opened through the inner bar by removing 28,192 cubic yards of sand, &c.

An appropriation of $10,000 was made by the act of July 11, 1870.

1871.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, in April, 1871.

In March a contract was made for cutting a channel through the inner bar one-half mile long, 90 feet wide, and 12 feet deep, at 26½ cents per cubic yard in position; operations were commenced in May, and by the close of the season 30,784 cubic yards of sand and clay had been removed.

1872.

An appropriation of $13,000 was made by the act of June 10, 1872.

A survey of the bay was made this season under the direction of General C. B. Comstock, the officer in charge of the survey of the lakes; a depth of 13 feet was found in the channel through the outer bar, and of about 11 feet through the inner bar. A contract was made for continuing the dredging through the inner bar, at 34 cents per cubic yard, and 34,000 cubic yards of sand, clay, &c., were removed during the season.

1873.

In January, 1873, Colonel Gillespie submitted an elaborate report, with a chart and plan of improvement for keeping the channel open through the inner and outer bars; the estimated cost of the whole work was nearly $1,000,000; he believed that any unprotected channel through the bay would gradually fill up; he recommended that the channel through the outer and inner bars should be deepened to 14 feet to the center of the area of deep water inclosed by the 12-foot curve in the bay, and estimated the cost of this part of the work at $50,000. The recommendation for deepening the channel was approved by the Chief of Engineers, and an appropriation of $25,000 was made by the act of March 3, 1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873.

A contract was made in June, 1873, for continuing the dredging in the channel within the bay, with two dredges, tugs, scows, &c., for the sum of $125 per day each when working and $10 per day each when idle from stress of weather.

Work was commenced in July, and by the close of the year a channel 75 feet wide and not less than 14 feet deep was completed through the inner shoal. Colonel Harwood reported that the channel could not be maintained without confining it between dikes.

1874.

An appropriation of $25,000 was made by the act of June 23, 1874. Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, Corps of Engineers, June 30, 1874.

A contract was made in September for two dredges, with tugs, scows, &c., at $90 per day each when working and $20 per day when idle from stress of weather, and work was immediately resumed widening and deepening the channel through the outer bar, which had again filled; operations were continued until November, when they were suspended for the season; 56,376 cubic yards of sand were removed from the channel during the year.

1875.

Operations were resumed in April, under the contract of September, 1874, upon the outer bar, and by June 30, 84,808 cubic yards of "fine treacherous running sand" had been removed since commencing work in September, 1874, under this contract.

An appropriation of $25,000 was made by the act of March 3, 1875, and a contract was made May 22 for four dredges with tugs, scows, &c., at the rate of $110 per day each when working and $25 per day each when idle from stress of weather.

Work was resumed upon the channel through the outer bar, and continued until September, a depth of 15 feet being gained; 129,142 cubic yards of fine sand, &c., were removed during the year. Colonel Blunt stated in his annual report for 1875 that he believed any unprotected channel through the bay would gradually fill up.

An examination of the bar in September, 1875, showed that there was a channel 100 feet wide with a least depth of 15 feet through the outer bar, and 150 feet wide with a depth of from 13½ to 15½ feet through the inner bar, but that this inner dredged channel stopped abruptly in a depth of 12 feet water about 1¾ miles from the docks of Sandusky City

1876.

In his annual report for June 30, 1876, Colonel Blunt reports that the residents of Sandusky were very anxious that the channel should be continued to the docks, and he estimated that it would cost $130,000 to complete the work as desired; he again stated his belief that the channel would fill up unless protected. An appropriation of $25,000 was made by the act of August 14, 1876, but did not become available in time for work during that season.

Colonel Blunt was relieved by Lieut. Col. and Bvt. Maj. Gen. N. Michler, Corps of Engineers, in December, 1876.

1877.

It was determined to continue the dredged channel towards the city front of Sandusky, and to make it 200 feet wide and 15 feet deep

Operations were commenced upon the channel within the bay with one dredge in May, excavating at the rate of 11¾ cents per cubic yard, and in June another was placed at work at the rate of 11 cents per cubic yard; under these contracts 101,879 cubic yards of mud and sand were removed during the season, work having been in progress both on the inner channel and the outer bar.

1878.

An appropriation of $20,000 was made by the act of June 18, 1878. Operations were resumed in April, under the two contracts of 1877, and were continued until August, during which period 63,042 cubic yards of sand, &c., were removed from the channel.

During the progress of work in 1877 and 1878 the channel through the outer bar was again widened to 150 feet with a least depth of 14 feet, and in one half of this width there was a depth of at least 15 feet.

The channel up as far as the last or "clock" range was deepened and widened, and work was commenced on that range.

In September a new contract was made at 12 cents per cubic yard, and work was commenced with two dredges on the "clock range" channel leading towards the city docks; 60,160 cubic yards of clay, sand, &c., were removed from this section of the channel up to the close of December, when operations were suspended for the season.

General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers, December 16, 1878.

OPERATIONS DURING 1879 AND THE FISCAL YEAR ENDING JUNE 30, 1880.

Operations were resumed in April, dredging in the "clock range" channel, and were continued during the months of April, May, and June upon the channel, and during July upon the outer bar, when they were suspended for the season, the appropriation having become exhausted. During this period 80,861 cubic yards of clay, mud, sand, &c., were excavated from the channel, 7,951 cubic yards of which were removed from the outer bar. An appropriation of $1,000 was made by the act of March 3, 1879, for the survey of the harbor; it became available in August, 1879.

An elaborate survey of the harbor was made in September and October, 1879, which developed the following facts:

First. After crossing the outer bar Sandusky Bay presents a good harbor, in which, throughout the greater portion, there is an average depth of about 11½ to 12 feet, while in other parts the depths vary from 15 to 12 feet.

Second. The channel through the bar outside of Cedar Point presents a full depth of 15 feet with a width of 100 feet for a length of 1,200 feet, gradually shoaling up to 13½ feet for an additional width of 50 feet on each side, and then shoaling to 12 feet.

Third. After crossing the outer bar the channel gradually widens and deepens until we get inside about half a mile from Cedar Point; here the dredged channel, which is marked by beacons, again commences and presents an average width of 200 feet and a depth of not less than 15 feet for a distance of about three-quarters of a mile; the direction then changes, the channel at the angle being about 300 feet wide with a least depth of 15 feet, and we run about half a mile on the new range with a width of about 200 feet, and a least depth of 15 feet. We then reach the "clock range," where for the first half mile we find a chan-

nel about 100 feet wide, with a depth of from 15 to 16 feet, shoaling up to 11½ feet at a distance of 50 feet on each side; for the remainder of the "clock range" to its terminus, a point about 400 feet from the outer line of docks, we have a channel about 175 feet wide with a depth of from 15 to 16 feet.

The channel ends abruptly at a point about 400 feet from the line of docks in a depth of about 10 feet of water. In the autumn of 1879 the Baltimore and Ohio Railroad Company dredged a channel about 50 feet wide and 15 feet deep from their docks to the "clock range" channel.

The total distance by way of the channel from the outer bar to the docks at Sandusky is 4¼ miles.

The original estimate made in 1876 to complete this channel up to the docks was $105,000; since that time $58,500 has been appropriated; owing to the reduced price for which the work has been done the project is now nearly completed; to finish this channel to carry it up to within 50 feet of the line of docks so that wharf owners can either build or dredge out to it, and to remove such deposits as may from time to time occur within the next year, the sum of $15,000 will be required for the fiscal year ending June 30, 1882, which will complete the project.

I think this channel should be continued parallel to the line of docks so that vessels coming in may run near the docks to which they are consigned.

I therefore recommend that it shall be prolonged to within 50 feet of the line of docks and then extended with a width of 100 feet and depth of 15 feet, a distance of 3,000 feet on one side and 1,700 feet on the other of the "clock range," as indicated upon the chart transmitted; this will require the removal of 120,000 cubic yards of clay, mud, &c., at an estimated cost of $25,000, which, with the $15,000 required to complete the project, as heretofore submitted, will render $40,000 necessary to complete the whole work.

During the present fiscal year it is proposed to devote the $12,500 appropriated by the act of June 14, 1880, to widening and deepening the channel where necessary from the outer bar up to within 100 feet of the docks at Sandusky.

In my last annual report I stated that I thought it would be necessary to revet this channel throughout its entire length; since that time I have made a careful study of the subject and an estimate of the cost of such a revetment; this estimate is as follows:

15,500 feet of pile pier, at $18	$279,000
24,500 feet of pile revetment, at $8.50	208,250
One crib for pier head	2,950
Contingencies, at 10 per cent	49,000
Total	539,200

Should this be constructed we would have nearly 8 miles of revetment subject to continual damage and necessary repairs, and I believe now that after the channel is once completed, with an annual appropriation for dredging of less than two per cent. of the estimated cost of the revetment, it can always be kept clear.

The total amount appropriated for this harbor up to the close of the present fiscal year is $225,080, of which amount $212,580 has been expended.

RÉSUMÉ.

It will be observed that the original survey of this harbor by the general government was made in 1826, but that no appropriation was

made until 1844. At that time (1844) the depth across the outer bar was 10 feet and after crossing it 11½ feet could be carried up to Sandusky. This depth was maintained until 1864, when its increase was recommended.

In 1869 the channel through the outer bar was 240 feet wide and 12 feet deep; in 1872 this depth was increased to 13 feet and work was commenced upon the channel within the bay; in 1875 there was a channel 100 feet wide and 15 feet deep through the outer bar, and one 150 feet wide and from 13½ to 16 feet deep within the bay up to within 1⅓ miles of the Sandusky docks; in 1879 there was a channel through the outer bar 100 feet wide with a full depth of 15 feet and with a depth of 13½ feet for a width of 50 feet on each side; the channel through the bay presented a full depth of 15 feet with a width of from 100 to 200 feet up to a point 400 feet from the line of docks.

It will thus be observed that the depth in the channel through the outer bar has been increased 5 feet and within the bay, 3½ feet.

Sandusky Harbor is in the collection district of Sandusky, Ohio; there is a lighthouse on Cedar Point, with a fixed white light of the fifth order. Fort Wayne, below Detroit, is the nearest work of defense.

I am unable to state the amount of commerce that will be benefited by this improvement, but the records of the custom-house show it to be considerable.

The amount of revenue collected during the eleven months, from July 1, 1879, to May 31, 1880, was $3,917. The value of the foreign imports during the same period was $28,411, and of the foreign exports $5,224.

Five hundred and eighty-nine vessels with an aggregate tonnage of 181,852 tons entered, and 578 vessels with an aggregate tonnage of 188,866 tons cleared during the same period.

An abstract of contracts in force and a financial statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$2,573 39	
Amount appropriated by act approved June 14, 1880	12,500 00	
		$15,073 39
July 1, 1880, amount expended during fiscal year		2,573 39
July 1, 1880, amount available		12,500 00
Amount (estimated) required for completion of existing project		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		20,000 00

Abstract of contract for improving harbor at Sandusky, Ohio, in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Date of contract.	Subject of contract.	Sand, clay, &c., per cubic yard in scows.	Remarks.
J. C. and J. H. Davis, Toledo, Lucas County, Ohio.	May 22, 1879.	Dredging	$0 12	Contract completed and closed July 21, 1879.

I I 5.

IMPROVEMENT OF SANDUSKY RIVER, OHIO.

HISTORY OF THE WORK.

The Sandusky River rises in Richland County, Ohio, and flowing first west and then a little east of north, after a very circuitous course empties into Sandusky Bay, about 14½ miles from Cedar Point light-house, where the bay empties into Lake Erie. Fremont, the head of navigation, is 17 miles from the mouth of the river; it is a city of about 9,000 inhabitants, and the market place of a large and productive surrounding country.

1866.

The attention of the general government was first called to the improvement of the Sandusky River by the act of June 23, 1866, in which a survey was ordered.

The work was placed in charge of Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, who submitted, in December, 1866, a chart of the river, with a plan and estimate for its improvement. The survey was made by Capt. and Bvt. Lieut. Col. F. U. Farquhar, of the Corps of Engineers, who descended the river from Fremont to Sandusky Bay.

General Cram reported the river to be deep and free from obstructions throughout the greater portion below Fremont, but that there were seven bars upon which there was a depth of from 5 to 9 feet, and which needed improvement, as follows:

Whitacre Bar, Nigger Point Bar, South Creek Bar, bar at the mouth of the river, and three others, designated as bars one, two, and three. He described the current of the river as gentle, and stated that except during the period of floods little or no silt was brought down to increase the deposits; the material was soft and easy to be dredged. He further stated that at Whitacre Bar and at the mouth of the river a channel had been dredged, 60 feet wide and 9 feet deep, at a cost of $17,000, which sum had been raised by subscription, the citizens having subscribed $12,000 and the county of Sandusky the remainder.

General Cram recommended that a channel should be dredged through the bars, with a depth of 10 feet and a width varying from 160 to 200 feet, depending on the locality.

The estimated cost of this project was $67,955.53.

1867.

The first appropriation of $20,000 was made by the act of March 2, 1867, and a contract was made to dredge a channel through the bars, at 27 cents per cubic yard. Work was commenced early in July and continued throughout the season, deepening the channel through the various shoals; 20,716 cubic yards of material were removed from the channel during the year.

1868.

Operations were resumed in April, 1868, and continued throughout the season; 20,981 cubic yards of mud, clay, &c., were removed from Whitacre Bar and 13,689 cubic yards from the bar at the mouth of the river.

1869.

General Cram was relieved by Maj. W. McFarland, Corps of Engineers, in April, 1869. Major McFarland at once made an examination of the river, and found that the chief impediments to navigation existed at the first shoal below Whitacre Bar and at the mouth of the river; the remainder of the available funds were applied to these localities; 210 cubic yards of sand and stone were removed from the former bar and 13,494 cubic yards from the latter during the season.

In his annual report for June 30, 1869, Major McFarland reported a good 8-foot channel, 60 feet wide up to Fremont, and that the appropriation was exhausted; he stated that until a depth of 12 feet could be carried through Sandusky Bay, it was useless to obtain 12 feet in the river; he asked for $20,000 to continue the work. The remainder of the funds on hand June 30, 1869, $349.44, in accordance with law reverted to the Treasury.

1870, 1871.

The Chief of Engineers in his annual reports for 1870 and 1871 renewed the application for $20,000, but no appropriation was made and no work done.

1872.

An appropriation of $10,000 was made by this act of June 10, 1872, for continuing the improvement. Maj. and Bvt. Col. G. L. Gillespie, of the Corps of Engineers, had in the mean time relieved Major McFarland. A contract was made in August for dredging a channel through the bars, at 25 cents per cubic yard.

Operations were commenced in October and continued until the last of November, when they were suspended for the season; 7,498 cubic yards of material were removed, a cut 60 feet wide and 9 feet deep made through Whitacre Bar, and one 400 feet long, 40 feet wide, and 9 feet deep, through a bar near Fremont, giving access to its elevators.

1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, Corps of Engineers, in April, 1873.

Operations were commenced early in April, dredging the channel off Eagle Island near the mouth of the river, and were continued until the last of June when the appropriation was exhausted. During this period a channel 1 mile long, 45 feet wide, and 9 feet deep was opened near the mouth of the river by removing 29,278 cubic yards of sand, &c. In his annual report for June 30, 1873, Colonel Harwood stated that a few bars in the upper part of the river needed some further dredging, but that the main work was to widen the cut from Eagle Island to the mouth of the river; he asked for $15,000 for continuing the work of improvement.

No further appropriation was made for this river, and no work done up to 1880.

1880.

In March, 1880, Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers, by direction of the Secretary of War, submitted a report upon the river; he asked for $20,000 for making temporary improvements and for surveys upon which to base a plan for permanent improvement. An appropriation of $10,000 was made by the act of June 14,

1880; this will be applied to dredging the channel of the river between Fremont and its mouth, and to making the necessary surveys and observations upon which to base a plan of improvement; an accurate estimate of the cost of a project of improvement cannot be made until these surveys are completed. For continuing the work of dredging, $15,000 can be profitably expended during the next fiscal year, and if appropriated will be applied to widening and deepening the channel through the bars.

Fremont, the head of navigation, is in the collection district of Sandusky, Ohio. The nearest light-house is on Cedar Point, at the entrance to Sandusky Bay. Fort Wayne, near Detroit, Mich., is the nearest work of defense.

The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $27. The imports were as follows: 1,763,000 feet, board measure, pine timber, 900,000 shingles, 200,000 laths, 6,650 barrels salt. The exports were as follows: 655,000 feet, board measure, oak lumber, 1,200 bushels of oats. Twenty-two vessels with an aggregate tonnage of 2,268 tons entered, and 22 vessels with an aggregate tonnage of 2,268 tons cleared during the first eleven months of the present fiscal year.

A financial statement is transmitted herewith.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	Project incomplete.
Amount that can be profitably expended in fiscal year ending June 30, 1882	$15,000 00

SPECIAL REPORT.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, March 2, 1880.

GENERAL: I have the honor to acknowledge receipt on yesterday of the letter of the 26th ultimo, from the Chief of Engineers, directing me to submit a report upon the improvement of the Sandusky River below Fremont, Ohio, and to prepare an estimate therefor. In reply I have the honor to report as follows:

The Sandusky River rises in Richland County, Ohio, and flowing first west and then a little east of north, after a very circuitous course empties into Sandusky Bay, about 14½ miles from Cedar Point light-house, where the bay empties into Lake Erie.

Fremont, the head of navigation, is 17 miles from the mouth of the river; it is a city of about 9,000 inhabitants, and has two elevators with a capacity of 200,000 bushels, four flouring mills, six saw mills, one woolen factory, large manufactories of reapers and mowers, steam-engines, wagons, and carriages, four lumber yards, three planing mills, &c.

It is the market place of a large and productive surrounding country, and the terminus of the Lake Erie and Western Railroad.

The attention of the general government was first called to the Sandusky River by the act of June 23, 1866, in which a survey was ordered.

The work was placed in charge of Col. T. J. Cram, of the Corps of Engineers, who submitted, in December, 1866, a chart of the river, with a plan and estimate for its improvement.

The survey was made by Maj. F. U. Farquhar, of the Corps of Engineers, who descended the river from Fremont to Sandusky Bay.

Colonel Cram reported the river deep and free from obstructions throughout the greater portion below Fremont, but that there were seven bars upon which there was a depth of from 5 to 9 feet, and which

needed improvement as follows: Whitacre Bar, Nigger Point Bar, South Creek Bar, bar at the mouth of the river, and three others, known as bars one, two, and three. He described the current of the river as gentle, and stated that except during the period of floods little or no silt was brought down to increase the deposits; the material was soft and easy to be dredged. He further stated that at Whitacre Bar and at the mouth of the river a channel had been dredged 60 feet wide and 9 feet deep, at a cost of $17,000, which sum had been raised by subscription, the citizens having subscribed $12,000, and the county of Sandusky the remainder.

Colonel Cram recommended that a channel should be dredged through the bars with a depth of 10 feet and a width varying from 160 to 200 feet, depending upon the locality. The estimated cost of this project was $67,955.53.

The first appropriation of $20,000 was made by the act of March 2, 1867, and a contract was made to dredge the channel through the bars at 27 cents per cubic yard; work was commenced early in July, 1867, and continued until the close of the season of 1868, during which period 55,346 cubic yards of mud, sand, &c., were removed from the various bars. In his annual report for June 30, 1868, Colonel Cram reported that the channel had been greatly improved, and asked for the remainder of the original sum estimated in order to complete the project.

In April, 1869, Major McFarland relieved Colonel Cram of the charge of the river. He made an examination of the channel soon after assuming charge, and finding the greatest trouble to be at the first shoal below Whitacre Bar and at the mouth of the river, applied the remainder of the appropriation of 1867, except about $350, to those localities, removing therefrom 13,704 cubic yards of mud, sand, &c.

In his annual report for the fiscal year ending June 30, 1869, Major McFarland asked for $20,000 to continue the work.

No appropriation was made in 1869, 1870, nor 1871, and a small balance of $349.44 from the appropriation of 1867 reverted to the Treasury in accordance with law.

The Chief of Engineers, in his annual report for 1870, again asked for $20,000 for continuing the work, and repeated his request in 1871.

By the act of June 10, 1872, an appropriation of $10,000 was made for continuing the improvement. Major Gillespie was in charge of the river at this time, and applied the appropriation as follows:

A channel 40 feet wide, 9 feet deep, and 400 feet long was dredged through a bar near Fremont, giving access to its elevators; off Eagle Island, near the mouth of the river, a channel 1 mile long, 45 feet wide, and 9 feet deep was opened. These operations exhausted the appropriation.

Major Harwood, who relieved Major Gillespie in April, 1873, asked for $15,000 to continue the work, but stated his belief that no permanent improvement could be made without resorting to dikes at the various bars.

Congress made no further appropriation after that of June 10, 1872, and the narrow channels have since shoaled so that at present there is a depth of only about 8 feet over the bars; except at the bars there is a depth of from 12 to 20 feet in the channel, as shown by Colonel Cram's chart.

A complete survey should now be made of the river from Fremont to the curve of 10 feet water in Sandusky Bay, and a project prepared for its improvement. As the depth in Sandusky Bay for a considerable distance from the mouth of the river varies from 9 to 10 feet, it would

be useless to attempt to obtain a greater depth in the river than can be carried through the bay.

For this survey, and for dredging through the various bars for immediate relief to the interests of commerce, the sum of $20,000 could be profitably expended during the next fiscal year.

Until a careful resurvey of the various bars is made, an estimate of the total cost of the work cannot be made.

A letter from Mr. George G. Hadley, superintendent of the Lake Erie and Western Railroad, to Col. W. E. Haines, of Fremont, explaining the necessity for deeper water in the river, is transmitted herewith.

Fremont is in the collection district of Sandusky, Ohio. The nearest port of entry is at Sandusky City. There is a light-house on Cedar Point, at the entrance to Sandusky Harbor, with a fixed white light of the fifth order, and range-lights in the bay.

Fort Wayne, below Detroit, is the nearest work of defense.

The amount of revenue collected at Sandusky City during the fiscal year ending June 30, 1879, was $5,102.64. The value of the foreign imports was $19,409. The value of the foreign exports was $63,125. Fourteen hundred and thirty vessels, with an aggregate tonnage of 263,516 tons, entered, and 1,442 vessels, with an aggregate tonnage of 265,694 tons, cleared during the year.

The commerce of the river below Fremont is said to have been considerable in grain, lumber, salt, plaster, &c., but I have been unable to procure exact statistics in reference to it.

I am, general, very respectfully, your obedient servant,

JOHN M. WILSON,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

LETTER OF MR. GEO. G. HADLEY.

LAKE ERIE AND WESTERN RAILWAY COMPANY,
OFFICE OF SUPERINTENDENT EASTERN DIVISION,
Fremont, Ohio, March 1, 1880.

SIR: I have the honor to reply to your inquiries relative to the present and future prospects of the Lake Erie and Western Railway Company.

By the consolidation of the Lake Erie and Louisville and Lafayette, Bloomington and Muncie Railways, which took effect January 1, 1880, a continuous line of railway, 352 miles in length, was organized under the name of the Lake Erie and Western Railway, the eastern terminus being Fremont, Ohio, and the western Bloomington, Ill., connecting at the latter city with the Chicago and Alton Railway, thus forming an unbroken line from Fremont to Kansas City, Mo., and the great southwestern grain-fields. This company have a large and complete elevator at Fremont, situated at the head of navigation, and they have just completed an extensive system of docks, which, in connection with the elevator facilities, will attract a large and lucrative traffic. The freight equipment of the company at present consists of 31 large and powerful locomotives, 2,000 box-cars, 125 stock-cars, and 400 lumber and coal cars, additions to which are to be made immediately to accommodate its rapidly increasing business. With reference to the passenger traffic, special attention has been given to this matter. New coaches, baggage and parlor cars have already arrived, fully equipped with the latest improvements—Miller platforms, Westinghouse air-brakes, patent heaters, and the like. I refer to this branch for the purpose of showing the desirability of this line as a route for summer and autumn excursions to Sandusky, Put-in Bay, Kelly's Island, &c., from which attractions our route has the undoubted preference.

In conclusion, I would state that the *present* facilities which the city of Fremont affords as a terminal point are entirely inadequate to the immense volume of business which this company will bring.

Respectfully submitted.

GEO. G. HADLEY,
Superintendent Eastern Division.

Col. WM. E. HAINES.

I I 6.

IMPROVEMENT OF HURON HARBOR, OHIO.

HISTORY OF THE WORK.

The Huron River rises in the northern part of Ohio, and flowing first in a northerly and then in a northeasterly direction, after a very circuitous course, empties in Lake Erie about 10 miles east of Sandusky City.

The attention of the general government was first called to the mouth of Huron River by the act of Congress approved May 20, 1826, wherein an appropriation of $5,000 was made for its improvement.

The work was placed in charge of Capt. T. W. Maurice, of the Corps of Engineers, who after a careful examination reported that the river was navigable for 6 miles for all vessels at that time engaged in the commerce of the lake, but that the usual sand bar, common to rivers emptying into the lake, existed at the mouth, and was bare at low-water; he submitted a project for parallel piers running out into the lake to confine the water of the river in a new channel across the bar; the estimated cost of the work was $15,349.12. This plan was approved and the work of collecting materials was commenced in the autumn of 1826.

1827.

Operations were commenced early in the spring, and such satisfactory progress was made that by the close of the season vessels drawing 6 feet water were enabled to enter the harbor.

1828.

An appropriation of $4,413.35 was made by the act of May 23, 1828; the piers built in 1827 had settled considerably and operations were confined during the season to restoring them to their original height; the channel continued to improve, the clay bottom having been reached by the current, and a depth of from 6 to 10 feet obtained.

1829.

An appropriation of $5,935 was made by the act of March 3, 1829; the west pier was extended to within 150 feet of its proposed terminus and the east pier to within 450 feet of its proposed terminus. They were both in an unfinished state. Up to the close of this season 2,040 linear feet of pier had been constructed and 600 feet yet remained to be built. The channel now presented a depth sufficient for the entrance of vessels drawing 7 feet.

1830.

An appropriation of $1,880.36 was made by the act of April 23, 1830. The west pier was prolonged 150 feet and the east pier 270 feet; the depth in the channel had increased to 8 feet.

1831.

An appropriation of $3,480 was made by the act of March 2, 1831. The east pier was prolonged 180 feet and the original project thus completed; both piers were strengthened and stone put in where the settlement had occurred.

1832.

An appropriation of $1,500 was made by the act of July 3, 1832. Maj. T. W. Maurice, who had been in charge of the work since its commencement, died suddenly March 5, 1832, and Mr. J. D. Selden was appointed agent under the Engineer Department. Operations were carried on during the latter part of the season, repairing and strengthening the work previously built.

1833.

No work was done during the year; the agent of the United States reported a least depth of 8 feet in the channel and that the piers required considerable stone to replace that which had settled.

By direction of the Chief of Engineers, Col. J. G Totten, of the Corps of Engineers, examined the harbor in the summer of 1833. He reported that the piers were about 1,400 feet long and projected about 1,000 feet in the lake, being 170 feet apart at their inner end, and 140 feet at their outer. He stated that there was now a straight channel at the entrance with a depth of from 10 to 12 feet, where the river was often completely closed by a bank of sand. Before work was commenced he recommended the construction of pier-heads 90 feet long, standing obliquely to the direction of the piers, so as to increase the width of the entrance.

1834.

An appropriation of $6,700 was made by the act of June 28, 1834, but on account of the prevalence of cholera no work was done.

1835.

Capt. Henry Smith, of the United States Army, who was in charge of the work at this time, reported considerable repairs to be necessary, and that the sand washed through the piers and threatened to restore the bar in the channel. A beacon-light was constructed this season on the outer end of the west pier.

1836.

Operations were confined this season to the repairs of the piers; an estimate was submitted for widening the base of the piers and constructing a masonry superstructure.

1837.

An appropriation of $2,565 was made by the act of March 3, 1837. Two hundred and ninety feet of the superstructure of the west pier and 60 feet of that of the east pier, which was badly decayed, was removed and rebuilt. Progress was made in the project for rendering the work permanent; an estimate of $46,431.85 was submitted for completing the plan for rendering the pier permanent and for dredging the harbor.

1838.

An appropriation of $5,000 was made by the act of July 7, 1838. One hundred and thirty feet of decayed superstructure was removed and rebuilt; the piers were refilled with stone where settlement had occurred. Piles were driven along the inner side of the piers for their protection and a quantity of stone engaged for the permanent project.

1839.

The available funds on hand were applied to the repairs of the piers. The expenditures up to this time had been as follows:

From 1826 to 1836 constructing piers	$26,973 75
From 1836 to 1839 repairing and strengthening piers	13,256 78
Total	40,230 53

The west pier was 1,587 feet long, and the east pier 1,400 feet long; the channel at its narrowest part was 130 feet wide and presented a depth of not less than 9½ feet water. No further appropriation was made nor work done until 1844.

1844, 1845.

An appropriation of $5,000 was made by the act of June 11, 1844, and the work was placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers. An examination of the harbor showed the piers to be in bad condition and that there was a depth of 10 feet in the channel except at one shoal place, where there was only 9 feet.

The repair of the west pier was at once commenced; at two places it was found necessary to entirely remove the timber work from 2 to 4 feet under water and to rebuild it; the entire pier was raised 1 foot for 1,350 linear feet, new snubbing posts were put in, and the whole re-planked. In the annual report for 1845 an estimate of $5,811.43 was submitted for repairing the east pier and dredging through the shoal, upon which there was only 9 feet of water.

The engineer in charge recommended that the channel should be deepened to 12 feet.

1852, 1853, 1854.

An appropriation of $10,000 was made by the act of August 30, 1852, and in 1853 the harbor was placed in charge of Capt. H. Stansbury of the Corps of Topographical Engineers.

By direction of the Chief of Topographical Engineers, the appropriation of August 30 was applied to repairing the east pier; 630 linear feet of that pier was rebuilt from an average of 3½ feet under water and 90 feet raised 3 feet above water to prevent breach between the new work and the shore.

A substantial pier head was built at the outer end of the pier upon the ruins of the old structure; it rose 9 feet above the water and was connected with 90 feet of new pier.

The west pier was very badly injured and the sea rolled into the harbor with a tremendous force, bringing in large quantities of sand which was deposited within the piers; the channel was reduced to a width of about 30 feet, the deposits on both sides reaching nearly across the harbor and coming nearly to the surface of the water; the freshets of 1853 improved the channel somewhat.

1854, 1855, 1856.

Captain Stansbury submitted estimates of $36,303 for rebuilding the piers, in his annual reports for these years.

1857.

In 1857 Col. J. D. Graham, of the Corps of Topographical Engineers who had relieved Captain Stansbury, submitted an estimate of $41,183.32

for putting the piers in order and dredging the channel; he asked for $30,000 at once, to save the harbor, which he considered one of great importance. No appropriation was made, however, until 1866.

1866.

An appropriation of $39,000 was made by the act of June 23, 1866, and the work was placed in charge of Col. and Bvt. Maj. Gen. T. J. Cram of the Corps of Engineers, who made a careful examination of the harbor and submitted a report with a plan and estimate for its improvement in September, 1866. He stated that the superstructure and part of the under-water work required renewal upon 1,080 linear feet of the west pier, while the outer portion of the east pier had been swept away and required to be rebuilt, and that the superstructure upon its entire length should be renewed. The depth of the outer bar was reported to be about 11 feet. General Cram recommended that the piers should at once be repaired at an estimated cost of $26,782. This recommendation was approved and contracts were made for the necessary repairs in October.

1867.

Operations were commenced early in the spring upon the repairs, and by the close of the season both piers were in comparatively good condition.

1868.

The old portion of the work was damaged by the gales during the winter of 1867–'68, and the necessary repairs were made during the year.

1869.

General Cram was relieved in April, by Maj. W. McFarland, of the Corps of Engineers.

Contracts were made in September for repairing the piers.

1870, 1871, 1872.

Both piers were put in good condition during the year, and various deposits of stone and sand were removed which had accumulated between the piers previous to their repair in 1867; a depth of 15 feet was obtained in the channel.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. Geo. L. Gillespie, in April, 1871. No work was done during the years 1871 and 1872.

1873.

Operations during this year were confined to the necessary repairs of the piers. Colonel Gillespie was relieved in April by Major and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers.

1874.

An appropriation of $1,500 was made by the act of June 23, 1874, and was expended in the removal by dredging of a shoal in the channel near the west pier and in minor repairs to both piers. Colonel Harwood was relieved in June, 1874, by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers.

1875, 1876, 1877.

An appropriation of $1,000 was made by the act of March 3, 1875, and was expended in the necessary repairs of both piers. No work was done in 1876 and 1877, there being no funds available. Colonel Blunt was relieved by Lieut. Col. and Bvt. Brig. Gen. N. Michler, of the Corps of Engineers, in December, 1876.

An examination of the piers in 1877, showed that the decking had been removed from part of the west pier, and stone removed, evidently for ballast.

1878.

An appropriation of $1,000 was made by the act of June 18, 1878, and was applied to the necessary repairs of the piers. General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers, in December, 1878.

OPERATIONS IN 1879 AND DURING THE PRESENT FISCAL YEAR.

The piers were carefully examined in the spring of 1879 and found to be in poor condition, the superstructure being weak and rapidly decaying; they were put in tolerably good order, minor repairs having been made at various points.

The engineer in charge stated, in his annual report for 1879, that the entire superstructure should be rebuilt, and that the short breakwater at the shore end of the west pier should be renewed; he estimated the cost at $25,000.

A survey was made of the harbor in October, 1879, which developed the fact that there was a good wide channel through the outer bar with a least depth of 14 feet at low-water, and between the piers, up to their inner ends, of from 14 to 17 feet, while, after getting inside, the river presented a depth of from 18 to 22 feet at low-water.

It was observed that as soon as the west pier, near its outer end, commenced flaring towards the northwest the depth almost immediately decreased from 15 to 14 feet.

During the present season it is proposed to rebuild the protection at the inner end of the west pier to prevent the lake from breaking through into the river.

Up to the close of the present fiscal year the sum of $101,273.71 has been appropriated for this harbor, of which $98,273.71 has been expended.

The entire superstructure of both piers should be renewed, at an estimated cost of $22,000. The sum of $8,000 could be profitably expended during the next fiscal year upon the renewal of the superstructure of the west pier.

RÉSUMÉ.

It will be observed, from the foregoing history of this harbor, that the work of improvement was commenced in 1826, at which time the mouth of the river was closed by a sand-bar, bare at low-water. In 1828 a depth of at least 6 feet was obtained in the channel; by the close of 1829, vessels drawing 7 feet were able to enter the harbor, and in 1839 the channel was 130 feet wide at the narrowest part, and presented a depth of not less than 9½ feet.

In 1844 this depth was found to have been maintained, but in 1852,

as but little work had been done for nearly 14 years, the piers were found to be dilapidated and the channel to have shoaled.

In 1866 a depth of 11 feet was reported at the entrance to the harbor, and by 1872 this depth had been increased to 15 feet.

In 1879 there was a good wide channel through the outer bar, with a least depth of 14 feet at low-water, and between the piers, up to their inner ends, of from 14 to 17 feet, while the river inside presented a depth of from 18 to 22 feet.

It will thus be seen that, with an expenditure of about $98,000, the entrance to this river has been kept navigable for over 50 years, and the depth gradually increased during that period from zero to over 14 feet.

Huron Harbor is in the collection district of Sandusky, Ohio. Fort Wayne, Mich., about 70 miles distant, is the nearest work of defense. There is a fixed white light of the fourth order on the outer end of the west pier.

I have no means of estimating the amount of commerce that will be benefited by this improvement, except from the records of the custom-house, which show the commerce to be very small.

The amount of revenue collected during the first eleven months of the present fiscal year was $18.50.

Eighteen vessels, with an aggregate tonnage of 2,495 tons, entered, and 20 vessels with an aggregate tonnage of 2,611 tons, cleared during this period.

A financial statement is transmitted herewith.

Money statement.

July 1, 1879, amount available	$827 87	
Amount appropriated by act approved June 14, 1880	3,000 00	
		$3,827 87
July 1, 1880, amount expended during fiscal year		827 87
July 1, 1880, amount available		3,000 00
Amount (estimated) required for completion of existing project		22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		8,000 00

I I 7.

IMPROVEMENT OF VERMILLION HARBOR, OHIO.

HISTORY OF THE WORK.

The Vermillion River rises in the northern part of Ohio, and, flowing first in a direction a little east of north and then slightly to the west of north, empties into Lake Erie about 20 miles to the eastward of Sandusky City.

The attention of the general government was first called to the mouth of this river by the act of Congress approved July 2, 1836, wherein an appropriation of $10,000 was made for its improvement, and the work was placed in charge of the Corps of Topographical Engineers.

The plan consisted of parallel piers running out to the depth of 12 feet in the lake from each side of the mouth of the river, and to secure a depth of 10 feet water between them. The estimated cost of the work was $74,342.34.

The survey made at this time showed the usual bar found at the mouths of rivers emptying into Lake Erie on its south side, with a depth of only from 1 to 2 feet water upon it. The aggregate length of the projected piers was 2,850 feet and their width 24 feet; the piers were to be

125 feet apart. Operations were commenced upon the construction of the west pier early in the fall of 1836, and were continued until the close of the season.

1837.

During this year 600 linear feet of the east pier were built and the west pier was prolonged 400 feet; the superstructure was not completed, however.

An additional appropriation of $20,000 was made by the act of March 3, 1837. The construction of the piers has already materially improved the channel.

1838.

An appropriation of $23,626.57 was made by the act of July 7, 1838. Operations were resumed in the spring of 1838, and during the season the superstructure of the previous year's work was completed and 500 linear feet of cribwork was added to that already built; the current of the river had now opened a channel from 6 to 7 feet deep and 50 feet wide through the bar. It was recommended that dredging should be carried on so as to obtain a depth of 10 feet between the piers, and the channel inside should be widened so as to allow vessels to turn after entering.

1839.

Work was continued in the spring of 1839, and at the close of the fiscal year, June 30, the west pier was 1,400 feet long and the east pier 800 feet long. It was proposed to prolong the east pier 350 feet, the west pier 400 feet, to add two pier-heads, each 50 feet square, and to dredge a channel 10 feet deep between the piers and a "winding" place inside. The estimated cost of the completion of this project was $27,811.55. No further appropriation was made for this work until 1866.

1845.

The charge of the harbor was this year assigned to Capt. A. Canfield of the Corps of Topographical Engineers. No regular appropriation was made for the work, but a small sum was allotted from the general appropriation for contingencies. Cribs as pier-heads were located, but were built only 2 feet above water.

The depth of the channel at this time was 10 feet; the piers were in bad condition and needed considerable repairs.

An estimate of $24,414.26 was submitted for repairing piers, prolonging the west pier 300 feet, and the east pier 230 feet, and dredging the channel to a depth of 11 feet.

1854.

In 1854 Capt. H. Stansbury, of the Corps of Topographical Engineers, made a careful examination of the harbor and found a depth of 8½ feet in the channel; he reported the under-water work of the piers to be in good condition, but recommended the renewal of the entire superstructure and the extension of the piers out into the lake; the estimated cost of repairing the piers and building pier-heads was $42,826.61. Some minor repairs were made to the outer end of the west pier under an allotment from the Light-House Board, in order to protect the beacon. The estimate of 1854 was renewed in 1855, '56, and '57, but no action was taken upon these recommendations.

1865.

In March, 1865, by direction of the Chief of Engineers, Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, made a careful examination of the harbor; he reported both piers to be in a dilapidated condition, a portion of the east pier having been carried away to 4 feet below the surface of the water; the depth in the channel between the piers was only 7 feet, and after an examination of the river for some miles above its mouth, General Cram stated that its volume was not sufficient to maintain a greater depth than 7 feet through the bar without continual dredging; he recommended that the piers should be repaired in the most economical way, and estimated the cost of putting them in order at $15,315.74.

1866.

An appropriation of $15,315.74 was made by the act of June 23, 1866. Contracts were made in the fall for repairing the piers, but no work was done on account of the lateness of the season.

1867.

Operations were commenced early in the spring, and were continued throughout the season, repairing the piers under and above water, and building them to a height of 5 feet above the surface of the lake. General Cram stated in his annual report for 1867 that, until further damage rendered it necessary, no more work would be done.

1868, 1869, 1870, 1871.

No work was done during these years, there being no appropriation for the harbor. Maj. W. McFarland, Corps of Engineers, was in charge from April, 1869, to April, 1871, when he was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, Corps of Engineers.

1872.

An appropriation of $5,000 was made by the act of June 10, 1872, and this was applied to deepening the channel; 2,216 cubic yards of rock were removed, and a channel gained 60 feet wide and 11 feet deep out into the lake.

1873.

An appropriation of $12,000 was made by the act of March 3, 1873. Colonel Gillespie was relieved in April, 1873, by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers. During this season the east pier was prolonged 132 feet, and the west pier 66 feet.

1874.

Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, in June, 1874. An appropriation of $3,000 was made by the act of June 23, 1874, which was applied to the repair of the piers. In September, Colonel Blunt submitted a project for widening the channel to 100 feet, and deepening it to 14 feet, at an estimated cost of $17,000.

1875.

An appropriation of $10,000 was made by the act of March 3, 1875, and the amount was applied during the season to excavating rock from

the channel between the piers. After the close of operations in October, Colonel Blunt submitted a report stating that funds were exhausted and that $11,000 were still required to complete the channel to the projected width and depth; careful surveys had developed more work than was anticipated when the estimates were submitted in 1874.

1876.

An appropriation of $5,000 was made by the act of August 14, 1876, but not being available during the year, no work was done. In his annual report for this year, Colonel Blunt asked for $6,000 more to complete the channel, and $3,000 for the repair of the piers.

Colonel Blunt was relieved by Lieut. Col. and Bvt. Brig. Gen. N. Michler, of the Corps of Engineers, in December, 1876.

1877.

The appropriation of August 14, 1876, became available in May, and a portion of it was applied to the necessary repairs of the piers.

1878.

An appropriation of $4,000 was made by the act of June 18, 1878, and in his annual report for that year General Michler stated that he had about $7,000 available for the harbor, which he recommended should be applied to obtaining a channel 60 feet wide and 13 feet deep out into the lake. Work was commenced in August, blasting and dredging, and 4,127 cubic yards of rock and 2,026 cubic yards of sand, &c., were removed during the season.

General Michler was relieved by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers, in December, 1878.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

There being no appropriation for this harbor in 1879, and the amount available being small, no work was attempted until October. During October and November minor repairs were made to both piers, which were put in tolerably good condition, and soundings were made from the docks in the river to the 15-foot curve in the lake and a chart prepared.

The soundings showed that the channel had again shoaled at the entrance to the piers, and that there was an underlying formation of rock upon which the depth varied from 8 to 15 feet, but that by dredging a channel could be obtained between the piers with a depth of 13 feet; the depth at the outer end of the piers was 11½ feet at low-water, which depth is available all the way up to the docks in the river, varying from 11 to 15 feet between the piers, and from 11 to 14 feet in the river.

In order to open a channel 100 feet wide and 14 feet deep from the lake to the lower end of the stone docks in the river, the following must be removed:

25,000 yards of sand, mud, &c., at 20 cents	$5,000
2,000 yards of rock, at $3	6,000
Total	11,000

This estimate is deduced from the survey made in November, 1879.

As the sand is slowly but steadily moving around the west pier into

the channel, it will be necessary, in order to maintain a depth of 14 feet, to prolong both piers 500 feet, at a cost of $50,000, but I do not think that the present limited commerce of the harbor would justify so large an expenditure at this time, and will not recommend this extension at present.

The piers are now in good condition; the east pier is 1,075 feet long, the west pier 1,125 feet long, and the channel between them 125 feet wide.

During the present season it is proposed, if funds are available, to make such minor repairs to the piers as may be necessary, and to dredge the channel at the entrance as far as the appropriation will admit.

The total appropriated for this harbor up to the present time is $109,942.32. Of this amount $107,942.32 has been expended to date.

The sum of $12,000 is required for deepening the channel, repairing piers, and completing the present project.

RÉSUMÉ.

A glance at the history of this work will show that operations were commenced in 1836, at which time there was a depth of only from 1 to 2 feet at the mouth of the river; in 1838 there was a channel 50 feet wide and 6 feet deep at the entrance; no further appropriations were made until 1866, but there was a depth of 8 feet in the channel in 1854.

In 1865 the piers were in a dilapidated condition, and there was a depth of only 7 feet in the channel; in 1872 there was a channel 60 feet wide and 11½ feet deep from the lake into the river, and in 1878 this was increased to a width of 70 feet, and depth of 12 feet.

Since that time a slight shoaling has taken place, but at least 11½ feet can be found in the channel between the lake and the inner end of the piers. It will thus be seen that with an expenditure of about $108,000 the entrance to this river has been kept navigable for over forty years, and the depth gradually increased during that period from 1 to about 12 feet, a portion of the excavation being in solid rock.

Vermillion harbor is in the collection district of Sandusky, Ohio. Stone and lumber are shipped from this port to a considerable extent, but I am unable to state the amount of commerce which will be benefited by maintaining the harbor. There is a fixed white light of the 5th order on the west pier. Fort Wayne, 80 miles distant, is the nearest work of defense. The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $24.50. The value of the exports during this period was $7,173. Thirty-six vessels, with an aggregate tonnage of 8,118 tons, entered, and 26 vessels, with an aggregate tonnage of 7,409 tons, cleared during this period.

A financial statement is transmitted herewith.

Money statement.

July 1, 1879, amount available	$574 74	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$2,574 74
July 1, 1880, amount expended during fiscal year		574 74
July 1, 1880, amount available		2,000 00
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		12,000 00

I I 8.

IMPROVEMENT OF BLACK RIVER, OHIO.

HISTORY OF THE WORK.

Black River, Ohio, is formed by two branches nearly equal in size, which, rising in Lorain County, Ohio, and running northward, unite about 8 miles from its mouth, and thence flowing onward empty into Lake Erie.

1828.

The attention of the general government was first called to the mouth of this river by the act of Congress approved May 23, 1828, wherein an appropriation of $7,500 was made for its improvement. The work was placed in charge of Capt. T. W. Maurice, of the Corps of Engineers, who made a survey and prepared a project of improvement. At the outlet of the river there was a bar with a depth of only 3 feet upon it, while the channel passing out turned abruptly to the westward. After crossing the bar, the river was navigable 4 miles from its mouth for any vessel that floated in Lake Erie.

The project of improvement consisted of parallel piers extending out from each side of the mouth of the river to the depth of 10 feet in the lake. The estimated cost of the work was $25,334.22. The plan was approved, contracts made, and work commenced under the appropriation of May 23, 1828.

1829.

Work was continued during the year, and the west pier was extended 840 feet into the lake. The depth upon the bar had already increased to 5 feet.

1830.

An appropriation of $8,559.78 was made by the act of April 23, 1830. The under-water work of the west pier was extended 390 feet, carrying it out to a depth of 10½ feet in the lake, and 540 feet of the under-water work of the east pier was built. The effect upon the channel was already very satisfactory.

1831.

An appropriation of $9,275 was made by the act of March 2, 1831. The superstructure was built upon the work sunk in 1830, and the east pier was prolonged 480 feet; the channel had already deepened to 8 feet.

1832.

An appropriation of $8,000 was made by the act of July 3, 1832. The outer end of the east pier, which had been badly damaged during the heavy gale in the fall of 1831, was repaired this year.

1833.

An appropriation of $2,400 was made by the act of March 2, 1833. The east pier was extended 450 feet, and the west pier 90 feet; and it was recommended that both piers should be revetted with stone on the

outside. The channel through the bar was now 200 feet wide and 7½ feet deep.

Col. J. G. Totten, Corps of Engineers, who inspected the work in the summer of 1833, reported that to complete the project by prolonging and revetting the piers and dredging the channel to a depth of 11 feet would cost, in addition to the funds then on hand, $17,700.

1834.

An appropriation of $5,000 was made by the act of June 28, 1834, and applied to deepening the channel to 9 feet.

1835.

Capt. Henry Smith, of the United States Army, was assigned to the charge of the harbor in 1835. He reported that the west pier extended 1,304 feet into the lake, the east pier about 1,200 feet, and that they were from 170 to 210 feet apart; the bar, which was then 360 feet from the outer end of the piers, was about 120 feet wide.

An appropriation of $4,400 was made by the act of March 3, 1835; the west pier was extended 40 feet, and the east pier 30 feet, and both were revetted and strengthened.

1836.

An appropriation of $6,660 was made by the act of July 2, 1836. The operations during this season consisted of the general repair and rebuilding of machinery for dredging, and the repair of the piers where they had been injured by storms. A project was submitted for widening the base of the piers and strengthening them.

1837.

An appropriation of $6,460 was made by the act of March 3, 1837. The piers were strengthened and revetted with stone; the dredging was continued, and a light-house erected on the outer end of the west pier. An estimate of $13,875 was submitted for continuing the improvement.

1838.

An appropriation of $5,000 was made by the act of July 7, 1838. The work of strengthening the piers and widening their bases, by means of piles and stone, was continued during the year, and an estimate of $25,000 was submitted for continuing the work.

1839.

An examination of the harbor this year showed that since 1828 the shore line had advanced 620 feet on the west side of the entrance to the river, and about 300 feet on the east side; the west pier extended from the shore line 759 feet into the lake, and the east pier 891 feet; the piers were 191 feet apart at their outer ends, 210 feet at the widest place near the shore, and 170 feet at their inner ends. There was a depth of 9½ feet water in the channel, which increased to 14 feet near the outer end of the piers. It was proposed to complete the dredging so as to have a depth of 10 feet water at all times. No further appropriation was made for this harbor until 1852.

1845.

There was no appropriation this year for this harbor, but an allotment of $4,000 was made from the general appropriation for repairs.

The work was placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers.

The piers were found to be in a dilapidated condition and there was a depth of only 9 feet on the bar.

Two breaches were closed in the east pier, its outer end secured, and it was thoroughly repaired. The west pier was raised 1 foot for 500 feet, and 750 feet was replanked. It was recommended that the west pier should be prolonged 100 feet, the east pier 200 feet, and that the channel be dredged to a depth of 12 feet; an estimate of $15,625.97 was submitted for this purpose.

1852.

An appropriation of $5,000 was made by the act of August 30, 1852, and the work placed in charge of Capt. Howard Stansbury, of the Corps of Topographical Engineers.

An examination of the harbor showed that the channel had shoaled somewhat and that the piers were in a dilapidated condition; a great portion of the east pier had been carried away to a depth of 6 feet under water.

1853, 1854, 1855, 1856.

The appropriation of 1852 was applied to rebuilding 300 feet of the west pier, and an estimate of $30,801.76 was submitted for putting the harbor in order. This estimate was repeated in the annual reports for 1854, 1855, and 1856.

1857.

In 1857 Col. J. D. Graham reported the piers to have become still more dilapidated, and asked for $33,881.93 to put them in order.

1865.

In March, 1865, Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers, made an examination of the harbor and submitted a report. He stated that the west pier was in fair condition, needing some repairs, while the east pier throughout nearly its whole length had been swept away to a depth of from 3 to 5 feet under water; the channel had shoaled very much; over more than half the area between the piers there was a depth of only 2 or 3 feet, but a narrow channel still remained near the west pier, with a depth of from 7 to 10 feet.

General Cram recommended that the piers should at once be put in order, and an allotment of $20,000 was made for this purpose from the general appropriation of June 28, 1864. Work was at once commenced, collecting materials and making the necessary repairs, and was continued throughout the season.

1866.

Operations were continued throughout the season of 1866, and at the close of the year General Cram reported that both piers had been entirely repaired and the east pier prolonged inside the harbor so as to

prevent the river from cutting around it. The channel at once began to improve. An appropriation of $10,000 was made by the act of June 23, 1866.

1867, 1868, 1869.

No work was done during these three years; in April, 1869, General Cram was relieved by Major Walter McFarland, of the Corps of Engineers.

1870, 1871.

Minor repairs were made to the piers during these years, and the channel was reported to have improved so that there was a depth of from 11 to 12 feet between the piers. Major McFarland was relieved in April, 1871, by Capt. and Bvt. Lieut. Col. George L. Gillespie, of the Corps of Engineers.

1872.

An appropriation of $20,000 was made by the act of June 10, 1872, and it was determined to apply it to repairing and prolonging the piers and dredging the channel. The east pier was prolonged 165 feet and the west pier 150 feet, and 23,000 cubic yards of sand were removed from between the piers. Violent gales prevented the dredge from working at the entrance to the piers, so that at the close of the season there was still a bar at that locality.

1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873. An appropriation of $20,000 was made by the act of March 3, 1873.

The west pier was extended 120 feet, and the east pier 220 feet, but the superstructure was not completed upon the outer portion; heavy gales and masses of ice damaged the outer cribs somewhat during the winter.

The outer bar was dredged so that there was a depth of 14 feet water from the lake into the river.

1874.

Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers, in June, 1874. An appropriation of $20,000 was made by the act of June 23, 1874.

The superstructure was completed upon the cribs sunk in the fall of 1873, and contracts were made for prolonging both piers out to a depth of 15 feet in the lake.

1875.

An appropriation of $10,000 was made by the act of March 3, 1875. Work was resumed early in the spring; the east pier was prolonged 90 feet, the west pier 120 feet, which placed their outer ends in 15 feet of water.

The channel was widened and deepened by removing 21,996 cubic yards of sand, &c.

1876, 1877.

In May, 1876, a violent gale seriously damaged the piers and threatened to cut through the shore around the inner end of the east pier; re-

pairs were at once made and a pile dike constructed at the inner end of the east pier. No work was done in 1877, there being no funds available. Colonel Blunt was relieved in December, 1876, by Lieut. Col. and Bvt. Brig. Gen. N. Michler, of the Corps of Engineers.

1878.

An appropriation of $1,000 was made by the act of June 18, 1878, and was applied to the repairs of the piers where necessary.

General Michler was relieved in December, 1878, by Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers.

OPERATIONS DURING 1879 AND THE PRESENT FISCAL YEAR.

There was no appropriation for this work in 1879, and the small amount available from the previous appropriation would not admit of commencing any work.

During the spring freshet of 1879, the west pier, about 230 feet from the shore, was undermined, and settled about 3 feet, the crib tearing away from the superstructure and the stone pouring into the channel.

An allotment from the general appropriation for contingencies was made for the necessary repairs, and work was commenced early in July, and by August 5 both piers were in comparatively good condition. The following materials were used in repairs:

7,888 feet, board measure, oak timber and plank.
1,754 feet, board measure, pine timber and plank.
9 cords of brush.
51¼ cords of stone.
340 pounds of drift bolts.
1,350 pounds of spike.

A survey was made of the channel from the swing-bridge in the river to the 16-foot curve in the lake, and a chart was prepared; this chart shows that there is a good wide channel with a depth of 15 feet across the outer bar, a depth of from 15 to 17 feet between the piers, and from 17 to 20 feet in the river up to the bridge.

During the winter of 1879-'80 there was some movement of sand around the end of the west pier, and a shoal was formed, not, however, of sufficient magnitude to interfere with navigation. In order to prevent further shoaling and to give this river a full depth of 16 feet at its entrance, which its importance and growing commerce demands, I respectfully recommend that the piers may be extended out to the depth of 16 feet in the lake; this will necessitate the prolongation of the west pier 180 feet and of the east pier 120 feet; the superstructure also requires to be renewed upon 2,000 linear feet of the piers.

The estimate for the above work is as follows:

Extending west pier 180 feet, at $60 per foot	$10,800
Extending east pier 120 feet, at $60 per foot	7,200
Renewing 2,000 feet superstructure, at $10 per foot	20,000
Contingencies, 10 per cent	4,000
Total	42,000

Of this amount $20,000 could be profitably expended during the next fiscal year.

This harbor is rapidly growing in importance; it is the lake terminus of the Cleveland, Tuscarawas Valley and Wheeling Railroad, which has now direct connection with the Ohio River; its coal, iron, and stone trade is daily increasing and becoming more valuable; at present the river is navigable, for vessels drawing 12 feet, 4 miles above its mouth.

Up to the close of the present fiscal year $176,138.73 has been appropriated for this harbor, of which sum $175,138.73 has been expended.

RÉSUMÉ.

It will be observed that operations for the improvement of this harbor were commenced in 1828, at which time there was a depth of only 3 feet at the entrance; by 1833 there was a channel 200 feet wide with a least depth of 7½ feet, and in 1839 there was a depth of 9½ feet in the channel, which increased to 14 feet as the lake was approached.

But one small appropriation of $5,000 was made between the years 1838 and 1865, and in the latter year the piers were found to be in a dilapidated condition, but a narrow channel still remained near the west pier, with a depth of from 7 to 10 feet; its width and depth were gradually increased, and in 1871 there was a depth of from 11 to 12 feet, and in 1874 a depth of 14 feet from the lake into the river; at present there is a good wide channel with a full depth of 15 feet from the lake up to the bridge across the river.

It will thus be seen that with an expenditure of about $175,000 the entrance to this river has been kept navigable for over 50 years, and the depth gradually increased during that period from 1 to 15 feet.

Black River Harbor is in the collection district of Cuyahoga, Ohio; the commerce is increasing, and the harbor is destined to take high rank among the harbors of the lakes. There is a fixed white light, of the fourth order, at the outer end of the west pier. The nearest work of defense is Fort Wayne, 80 miles distant, near Detroit, Mich.

The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $185.90. The value of the imports during this period was $347,126, and of the exports $250,496. One hundred and thirty-seven vessels, with an aggregate tonnage of 24,889 tons, entered, and 161 vessels, with an aggregate tonnage of 29,364 tons, cleared during the eleven months.

A financial statement is transmitted herewith.

Money statement.

July 1, 1879, amount available	$65 85	
Amount appropriated by act approved June 14, 1880	1,000 00	
		$1,065 85
July 1, 1880, amount expended during fiscal year		65 85
July 1, 1880, amount available		1,000 00
Amount (estimated) required for completion of existing project		42,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		20,000 00

I I 9.

IMPROVEMENT OF MOUTH OF ROCKY RIVER, OHIO.

HISTORY OF THE WORK.

Rocky River, Ohio, rises in the northern part of Ohio, and flowing north empties into Lake Erie at a point about 5 miles west of Cleveland.

1870.

The attention of the general government was first called to this locality by the act of Congress approved July 11, 1870, wherein a survey of

the mouth of the river was ordered. This survey was made under the direction of Maj. W. McFarland, of the Corps of Engineers, in October and November, 1870.

1871.

In January, Major McFarland submitted a chart of the harbor with a plan and estimate of its improvement. The following is an extract from his report:

The survey of this river was limited to that portion lying below the bridge over which the main road from Cleveland to the west passes, as no part above the bridge could be rendered available for the purpose of navigation.

By examining the map it will be seen that in its passage from the bridge to Lake Erie, a distance of about 1,000 yards, the river divides into two branches, which, after encompassing an upper and a lower island, unite again and enter the lake between a high rocky bluff on the west and a low sand spit on the east.

The eastern branch varies from 150 to 250 feet in width and the western branch from 75 to 100 feet in width. The depth of water from the bridge to the head of the upper island varies from 2 to 3 feet; here, however, it begins to deepen slightly, and near the foot of the island 6 feet water is found; this depth, with four slight variations, is carried to the outer bar, where the water shoals again to nearly 4 feet.

Soundings were taken over this whole area from the bridge to the 13-foot curve in the lake, at distances, of 10 feet, on lines averaging 100 feet, apart, and borings to the rock substratum were also made at distances of 20 feet apart, on lines averaging 200 feet apart. The results attained show that the bottom consists of sand chiefly, below which, at depths varying from 1 to 4 feet, rock is found.

Major McFarland reported that to make the harbor available, either for commercial purposes or as a harbor of refuge, would require a large amount of dredging and the construction of an east pier.

1872.

The first appropriation, of $10,000, was made by the act of June 10, 1872. Maj. and Bvt. Lieut. Col. George L. Gillespie, Corps of Engineers, then in charge of the work, recommended that the appropriation should be applied to the construction of a pier starting from the sand beach on the east side of the river, about 250 feet from the bluff on the west side, and running out into the lake. This project was approved and contracts were made for the work. In the annual report for 1872, Colonel Gillespie stated that no further appropriations were recommended.

1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873.

Operations were commenced upon the construction of the east pier in April and continued until the last of August, when 360 linear feet of it was completed.

In his annual report for June, 1873, Colonel Harwood submitted an estimate of $250,000 for completing the harbor and $50,000 for work for the ensuing year, closing his report as follows:

I accordingly make this estimate, it being understood that such estimate conveys no recommendation for further appropriation—a matter which is respectfully submitted to the better judgment of Congress.

1874.

An appropriation of $10,000 was made by the act of June 23, 1874. Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers, June 30, 1874.

Contracts were made in August for extending the east pier; work was commenced in September, and by the close of the year the pier had been prolonged 288 feet.

1875.

An appropriation of $15,000 was made by the act of March 3, 1875. Contracts were made in June for prolonging the east pier and dredging the channel at the entrance. Operations were commenced in August, and by the close of the year the east pier had been prolonged 180 linear feet, and 31,820 cubic yards of sand and shale had been removed from the channel.

1876.

Some minor repairs were this year made to the outer end of the pier. In his annual report for 1876, Colonel Blunt made the following statement:

Sufficient money is thought to have been expended at this point, and no further extension is recommended.

No further work was done, nor any further appropriations made for this harbor.

1878.

The freshet in the spring of 1878 cut a new channel through the sand beach around the inner end of the pier, undermined and carried away about 80 feet of the pier, and seriously damaged the work.

1879.

In July, 1879, Maj. and Bvt. Col. John M. Wilson, Corps of Engineers, reported the damage that had occurred during the previous year and submitted an estimate of $5,000 for the repair and preservation of the pier.

1880.

An appropriation of $4,000 for the repair of the pier was made by the act of June 14, 1880. This sum will be applied to the repairs, and it is anticipated that it will be sufficient for that purpose.

The total amount appropriated for this work up to the close of the present fiscal year is $39,000, of which sum $35,000 has been expended.

No further appropriation is asked for.

Rocky River is not a port of entry. It has no commerce, and unless a large sum is expended for its improvement, it is not probable that it will have any commerce for many years.

The general government is now constructing a large harbor of refuge at Cleveland, Ohio, 4 miles to the eastward. The nearest light-house is at Cleveland, Ohio, and the nearest work of defense is Fort Wayne, 106 miles distant.

A financial statement is submitted herewith.

Money statement.

Amount appropriated by act approved June 14, 1880	$4,000
July 1, 1880, amount available	4,000

I I 10.

IMPROVEMENT OF CLEVELAND HARBOR, OHIO.

HISTORY OF THE WORK.

The attention of the general government was first called to this harbor fifty-five years ago by the act of March 3, 1825, whereby an appropriation of $5,000 was made for a pier at the mouth of the Cuyahoga River, Ohio.

The Cuyahoga River rises in the northern part of Ohio, and flowing first south, then west and then north, after a very circuitous course, empties into Lake Erie.

At the time of the inauguration of work in 1825, the river emptied into the lake a little to the westward of the present west pier; a long, low sand-bar ran out from the east shore across the present entrance, and the depth on the outer bar was only from 3 to 4 feet, while after crossing it there was a depth of 15 feet in the river. Previous to 1825 the local authorities had attempted some improvement, but the work was primitive in style and did not produce the desired results.

The work was placed in charge of Capt. T. W. Maurice, of the Corps of Engineers, who submitted a plan for parallel piers or jetties, contracting the channel so that the increased velocity would scour out the bar; it was proposed to carry these jetties out to the depth of 12 feet in the lake and to obtain a channel 200 feet wide with a depth of 12 feet; the estimated cost of the work was $27,653.91.

This plan was approved, but no work was done on account of the limited funds available.

1827.

An appropriation of $10,000 was made by the act of March 2, 1827, and work was at once commenced; a dam 255 feet long was thrown across the mouth of the river in order to direct the current on the proper line, and materials were purchased for the purpose of renewing operations early in 1828.

1828.

The dam built in 1827 was found to have had the desired effect, the river having made a straight cut through the bar.

Up to September 30, from the commencement of the work, 1,275 linear feet of pier and 300 linear feet of dike had been completed.

The new channel had greatly improved and already presented a depth of from 6 to 8 feet of water.

1829.

An appropriation of $12,179 was made by the act of March 3, 1829. Work was resumed early in the spring, and during the season the west pier was prolonged 273 feet and the east pier 519 feet. To complete the project the east pier had yet to be extended 450 feet, and both piers still required to be covered and completed.

Owing to the dryness of the season and consequent absence of freshets, the depth in the channel remained about the same as in 1828.

1830.

An appropriation of $1,786.56 was made by the act of April 23, 1830. The east pier was completed except the pier head, and the west pier was planked to its outer end.

1831.

An appropriation of $3,670 was made by the act of March 2, 1831. The west pier was completed, and a beacon-light erected on its outer end. There was now a good channel with a depth of not less than 10 feet at the entrance; it was proposed to complete the work by strengthening the dam first built, and to remove a small sand-spit from the artificial channel near the dam.

Up to the close of this year 3,675 linear feet of piers and dikes had been constructed.

1832.

Major Maurice, who up to this time had been in charge of the work, died suddenly on March 5, 1832, and the harbor was placed in charge of Mr. J. D. Selden as agent for the Engineer Department.

An appropriation of $6,600 was made by the act of July 3, 1832, and was applied to filling in the piers where the stone had settled, and strengthening and repairing them where they had been damaged by collision of vessels or by storms.

1833.

By direction of the Chief of Engineers an examination of the harbor was made in the summer of 1833 by Col. J. G. Totten, of the Corps of Engineers, who reported as follows:

> The map of the mouth of the Cuyahoga River submitted herewith shows that a draught of at least 11 feet water can now be carried between the piers into the river, although the mouth previous to these improvements was at times entirely closed. The piers which have wrought this improvement are for the greater part parallel, running about 1,200 feet into the lake and having between them a channel of about 200 feet in width.

Colonel Totten recommended that the superstructure of the piers should be raised to prevent the sea from rolling over them during heavy gales; he estimated that the sum of $13,315 was required for strengthening the piers, building pier-heads, &c.

1834.

An appropriation of $13,315 was made by the act of June 28, 1834. Operations during the year were confined to strengthening and repairing the piers. The depth of water in the channel continued the same as in 1833.

An estimate of $125,320 was submitted for constructing a stone superstructure.

1835.

Lieut. T. S. Brown, of the Corps of Engineers, was assigned to the charge of the harbor this year. Work was confined during the season to riprapping the outside of the piers, driving piles to support the foot of the permanent stone mole authorized, and sinking an additional crib for the protection of the beacon.

1836.

An appropriation of $15,000 was made by the act of July 2, 1836.

The operations this year were conducted chiefly with reference to the ultimate design of rendering the work permanent; for this purpose about 6,500 cubic yards of stone were deposited on the outside of the piers, and timber, piles, large stone, &c., were collected; the piers were repaired where they had been damaged by the winter gales.

1837.

An appropriation of $10,000 was made by the act of March 3, 1837. Operations were continued upon the project for rendering the work permanent. From the head of the east pier to the shore an inclined plane of loose stone was formed, having a base of twice its altitude and rising above the surface; the timber was removed from the pier down 2 feet under water and replaced by permanent masonry of large blocks of stone strongly doweled together and laid in hydraulic cement, and the whole surmounted by a coping of cut stone for a length of 180 feet. A row of piles was driven on the outside of the west pier, 30 feet from it, and the space between the piles and the pier filled with stone so as to form an inclined plane from the piles up to the pier.

Some repairs were made to the piers where absolutely necessary.

1838.

An appropriation of $51,856 was made by the act of July 7, 1838.

Work was rapidly pushed forward this season; 454 piles were driven, 11,646 perches of stone were deposited between the piles and piers as before described, and 729 perches of rectangular blocks dressed and deposited on the pier ready to be laid. The west pier was thoroughly repaired.

1839.

The stone cut in 1838 was laid during the season. The west pier at this time was 1,470 feet long, the east pier 1,500 feet long, and it was not intended to prolong them; they fulfilled the end in view and there was at all times a good channel at the entrance to the river, with a depth sufficient to enable the largest class of vessels navigating the lakes to enter.

Between the years 1825 and 1839, the population of Cuyahoga County, Ohio, increased from 10,000 to 36,000, and of the town of Cleveland, from 600 to 9,000; the value of the county and town property, as given by the assessors, had increased from $1,032.494 to $6,134,000. The number of vessels entering the harbor had increased from 75 in the year 1825 to 2,413 in the year 1838, while the value of imports and exports was reported to have increased during this period from $182,871 to about $20,000,000.

An estimate of $66,721.46 was submitted in 1839 for completing the stone superstructure of the piers.

1840, 1841, 1842, 1843.

No appropriations were made during these years, and no work was done.

1844.

An appropriation of $25,000 was made by the act of June 11, 1844, and the work was placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers.

An examination of the harbor showed the piers to be in a dilapidated condition, and in October, 1844, operations were commenced upon the incomplete superstructure of the east pier and pushed vigorously until December; 438 linear feet of the stone work was partially rebuilt, clamped, and strengthened; the west pier was in a most dilapidated condition and required to be entirely rebuilt from the water-level up. The channel in the shoalest portion indicated a depth of 10½ feet.

1845.

Work was resumed in the spring of 1845, and the masonry superstructure of the east pier was completed.

The engineer in charge submitted an estimate of $62,562.35 for the following work: 1st. Repairing the west pier. 2d. Extending west pier 250 feet, with a pier-head 40 feet wide. 3d. For a permanent superstructure upon the west pier.

1846, 1847, 1848, 1849, 1850, 1851.

No appropriation was made during these years, and no work was done by the United States.

1852.

By the act of August 30, 1852, an appropriation of $30,000 was made for the harbor, and the work was placed in charge of Capt. Howard Stansbury, of the Corps of Topographical Engineers.

A careful examination of the harbor was at once made, and while the depth in the channel had not decreased, the piers were found to be in bad condition and to require immediate repairs.

1853.

Operations were commenced early in the spring, and 450 linear feet of new pier was built, occupying a line on the natural bottom of the lake outside the dilapidated west pier. Materials were collected during the winter for continuing the work.

1854.

During this year 150 feet of the old west pier was rebuilt, 350 linear feet added to the outside pier built in 1853, and the two piers connected in a substantial way; 300 linear feet of the east pier was repaired. The outer end of the east pier, which was built of cut stone, laid upon wooden cribs under water, had been seriously damaged by vessels running into it, and was in a most dilapidated condition.

Captain Stansbury submitted an estimate of $47,611.08 for putting the piers in order.

1855, 1856. 1857.

Captain Stansbury repeated his estimate for repairs in his annual reports for 1855 and 1856, and Lieut. Col. J. D. Graham asked for the same amount in 1857.

No further appropriation was made until 1864.

1864.

In September, 1864, Col. T. J. Cram, of the Corps of Engineers, made an examination of the harbor, and submitted a report and an estimate for its improvement. He stated that the west pier needed considerable repairs, and that the east pier, which was also in bad condition, was practically in the hands of the railroad companies and used as wharves. The bar at the entrance needed dredging, so that vessels drawing 12 feet could enter at all times, its condition being such as not to admit vessels of greater draught than 11 feet.

Colonel Cram recommended that the west pier should be immediately rebuilt at an estimated cost of $20,836; that the parties who had seized the east pier should at once be dispossessed; that the pier should be thoroughly repaired at their expense, and that an act of Congress should be passed prohibiting the use of government piers for private purposes.

1865.

Work was commenced early in 1865, under an allotment of $20,000 from the general appropriation of June 28, 1864. The west pier was thoroughly repaired; but as private parties still held possession of the east pier, nothing was done to it.

General Cram recommended that the west pier should be extended by pile work 500 feet into the lake, and the east pier 575 feet, and that the channel should be deepened to 14 feet. The estimated cost of the proposed extension of the piers was $59,806.

1866.

An appropriation of $59,806 was made by the act of June 23, 1866. The proposed prolongation of the piers was approved, and contracts were made for the work in October, 1866.

1867.

Operations were commenced in the spring of 1867 upon the west pier, and continued throughout the season. About 300 linear feet of pile pier was constructed.

1868.

General Cram was relieved in May by Maj. Walter McFarland, of the Corps of Engineers. An allotment of $17,000 was made from the general appropriation of June 30, 1868, for continuing the work. Operations were resumed in April, and by the close of the season the west pier had been extended 200 feet and completed, and the east pier extended 385 feet.

1869.

Work was commenced early in the spring upon the east pier which was prolonged 175 feet and completed.

In his annual report for this year, Major McFarland condemned the character of the pile pier which had been constructed during the previous three years, and showed that it was neither as strong nor as durable as crib work, and much more expensive. An allotment of $12,000 was made from the general appropriation of April 10, 1869.

1870.

Operations during this year were confined to the necessary repairs of the piers. An appropriation of $20,000 was made by the act of July 11, 1870.

1871.

A contract was made in March for deepening the channel at the entrance to the river by removing 30,000 cubic yards of sand, &c., at the rate of 25 cents per cubic yard, and $25 per day for each dredge when idle from stress of weather.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, in April, 1871.

Operations were commenced in April, and by the close of October 65,664 cubic yards of sand and gravel had been removed, and a depth of 16 feet at the entrance obtained. The east and west piers were both extensively repaired where they had been damaged by storms and by vessels running into them.

1872.

Operations during the year were confined to repairing the piers where necessary.

1873.

Colonel Gillespie was relieved in April by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers. An appropriation of $1,000 was made by the act of March 3, 1873, which was applied to the necessary repairs of the piers. A survey was made and a plan presented for an outer breakwater for a harbor of refuge during the latter part of this year, in accordance with the act of Congress approved March 3, 1873.

1874.

The piers again needed extensive repairs, and for this purpose all available funds were exhausted in the early part of the season.

An appropriation of $30,500 was made by the act of June 23, 1874.

Colonel Harwood was relieved June 30 by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers.

Work was commenced in the fall, under contract, strengthening and rebuilding the pile piers by driving additional rows of piles on each side, securing the rows by ties and rods, and filling with stone; the repair of the west pier was completed during the year.

1875.

Work was commenced early in the spring strengthening the east pile pier in a similar way to that done for the west pier last year, and by the close of the season both piers were in good order.

By the act of March 3, 1875, an appropriation of $50,000 was made for a breakwater in 5 fathoms water to protect the commerce of Cleveland, Ohio.

A Board of Engineers was convened in June, which, after carefully examining the whole subject, submitted a report recommending that a breakwater should be constructed on the west side of the mouth of the Cuyahoga River, as follows:

First a pile pier, starting from a point on shore about 700 feet west of the extremity of the old bed of the Cuyahoga River, extending into the lake on a line running about

north 10 degrees west (and making an angle with the general shore line of about 68 degrees) to the 14-foot curve, a distance of 1,000 feet; the width of the pier being 15 feet, the height above water about 7 feet, and both sides being well riprapped. From the 14-foot curve the line is proposed to be continued by crib work filled with stone resting upon a foundation of rubble stone 5 feet thick and riprapped on both sides as fast as cribs are sunk, the riprap having on the outside a height of about 8 feet above the bottom and a base of 16 feet, and on the inside a height of 5 feet and base of 10 feet. At a point 1,400 feet beyond the end of the pile-pier construction and 2,400 feet from shore the direction of the line is to be changed to one nearly parallel to the shore, and lying in an average of 27 feet of water. The line parallel to the shore is to extend about 4,700 feet to a point nearly in the prolongation of the present west channel pier, which it is proposed to extend about 600 feet, leaving an opening into the new harbor of about 300 feet.

The Chief of Engineers forwarded this plan to the Secretary of War, closing his communication as follows:

It is therefore recommended to the favorable consideration of the Secretary of War with this modification, that to conform more nearly to the requirements of the law the western part of the proposed work be so extended that the portion parallel with the shore shall rest in about the same depth of water as the 5-fathom breakwater projected by Lieutenant-Colonel Blunt, upon the plan of which the appropriation was based, and that the west pier of the existing harbor work be correspondingly extended.

This plan was approved by the Secretary of War, and consequently the west arm of the breakwater, instead of being 2,400 feet long as originally proposed, will be 3,130 feet long, the west pier at the mouth of the Cuyahoga River will be extended 1,000 feet instead of 600 feet, and the portion of the breakwater parallel to the shore will be sunk in water about 3 feet deeper than planned by the Board.

In September, 1875, the United States acquired title to a piece of land upon which to locate the shore end of the breakwater. Operations were commenced November 20th, under contract, constructing the pile pier, but were more or less interrupted during the winter by stormy weather.

1876.

Work was resumed early in the spring upon the shore arm of the breakwater, and by the close of the year 1,000 feet of pile pier and 150 feet of cribwork were completed.

An appropriation of $50,000 was made by the act of August 14, 1876, for continuing the breakwater, and one of $8,000 for repairing the old portion of the east pier, then in possession of the railroad companies.

1877.

The appropriation of $8,000 was expended in thoroughly repairing the east pier during the year 1877, and in accordance with the terms of the act of August 14, 1876, the portion occupied by the Cleveland and Pittsburgh Railroad Company was transferred to that company with the understanding that the company will hereafter keep it in repair.

A contract was made in May, 1877, for the construction of 400 linear feet of the new breakwater on the prolongation of the portion already built. Work was commenced in the fall of the year and the rubble-stone foundation for the cribs was completed.

1878.

Colonel Blunt was relieved by Maj. W. McFarland, of the Corps of Engineers, in January, 1878.

During the year the breakwater was prolonged 400 feet, making its total length 1,550 feet, with its outer end resting in 17 feet water.

An appropriation of $100,000 was made by the act of June 18, 1878, and a contract was made for extending the breakwater 1,000 feet. Operations were commenced upon the foundation in October, and by the close of the season 4,306 cubic yards of stone had been delivered. Major McFarland was relieved on December 27 by Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers.

OPERATIONS IN 1879, PREVIOUS TO JULY 1.

An appropriation of $100,000 was made by the act of March 3, 1879.

Operations were commenced in January, building foundation and constructing cribs for the new breakwater under contract, and by the last of June the foundation had been completed for a length of 1,000 feet and 500 linear feet of cribwork had been sunk.

The west pier was thoroughly repaired near its outer end where it had been cut down to the water's edge by a vessel striking it in the fall of 1878.

The channel at the mouth of the Cuyahoga River was deepened so as to present a depth of from 15 to 16 feet up to the bridge, by removing 8,391 cubic yards of mud, sand, loose rock, &c., 27 old piles, and 12 large blocks of stone weighing from 1 to 2 tons each.

OPERATIONS DURING THE PRESENT FISCAL YEAR—THE NEW BREAKWATER.

The opening of the fiscal year found operations in progress constructing the new breakwater under contract with Mr. F. B. Colton, of Washington, D. C.; work was continued until December 15, when the contract was completed.

During this period 500 linear feet of cribwork was sunk, and 1,054 linear feet of superstructure built to a height of 8 feet above the water. In the construction of this work the following materials were used:

1,027 cubic yards of foundation stone.
16,316¼ cubic yards of filling stone.
5,620½ tons of riprap stone.
579,720 feet, board measure, of hemlock timber.
545,785 feet, board measure, of pine timber.
85,834 feet, board measure, of pine plank.
3,213 pounds of screw-bolts.
96,647 pounds of drift-bolts.
10,670 pounds of spike.

The average cost of the breakwater built during the year 1879 in water varying from 17 to 25 feet deep was $70 per linear foot.

Two hundred and eight cubic yards of stone were placed in the pile portion of the breakwater where settlement had taken place.

In September, 1879, a contract was made with Messrs. Sherwood & Geissendorfer, of Cleveland, Ohio, for prolonging the breakwater 1,000 linear feet. Work was commenced in October and operations were continued through the winter constructing foundation and building cribs; by the close of the fiscal year 550 linear feet of the foundation had been completed and 300 linear feet of cribwork sunk; in the performance of this work the following materials were used:

1,085 cords of foundation stone.
1,170 cords of filling stone.
230 tons of riprap stone.
437,556 feet, board measure, of hemlock timber.
2,052 feet, board measure, of hemlock plank.

22,788 feet, board measure, of pine timber.
508 treenails.
4,284 pounds of screw-bolts.
37,745 pounds of drift-bolts.
350 pounds of spike.

The length of the shore arm of this breakwater will be 3,130 feet, the lake arm 4,000 feet, and the west pier at the mouth of the Cuyahoga River will be prolonged 1,000 feet, making a total length of 8,130 feet; up to the close of the fiscal year 2,550 feet had been entirely completed and 300 linear feet of cribwork sunk in addition.

The honorable Secretary of War has directed that the dock line within this new harbor shall be established at the depth of 12 feet water; this will give a good harbor of refuge of about 200 acres between the line of docks and the breakwater.

The estimated cost of this work is $1,800,000; unless some unforeseen contingency should arise, I believe the harbor can be completed for $1,500,000. The amount appropriated up to the close of the present fiscal year is $425,000, of which sum $200,858.44 has been expended; about $12,000 of this amount has been expended for repairing piers and dredging at the mouth of the Cuyahoga River.

During the present season it is proposed to complete the 100 linear feet of breakwater already contracted for, and to continue the work as long as the weather will admit, under the appropriation made by the act of June 14, 1880.

MOUTH OF THE CUYAHOGA RIVER.

The superstructure upon the portion of the west pier built in 1854 was in such a dilapidated condition that it was liable to be breached at any time. A contract was made for its renewal, and work was commenced in July; 737 linear feet of this superstructure was removed to the water's edge and rebuilt in a substantial manner. In the performance of this work the following materials were used:

127,720 feet, board measure, of pine timber.
27,365 feet, board measure, of pine plank.
184¼ cords of stone.
11,059 pounds of drift-bolts.
967 pounds of spike.

The east pier was thoroughly repaired in the fall of 1879 where it was badly damaged for a length of 80 feet by a vessel pounding against it during a gale, and again repaired in May, 1880, where it had been damaged in a similar manner.

At the close of the fiscal year both piers were in comparatively good condition, although the stone had again settled in the pile portion of the piers built in 1867.

By authority of the Chief of Engineers a contract was made for dredging at the mouth of the Cuyahoga River in the spring of 1880, and work was commenced in March and continued until the last of May. During this period 12,802 cubic yards of mud, clay, sand, stone, &c., and 6 large blocks of stone were removed. At the close of the year the channel between the piers presented a depth of from 16½ to 18 feet, with a width of from 150 to 200 feet, and through the outer bar a depth of from 17 to 19 feet, with a width of 250 feet. This is a greater depth than the entrance of the harbor of Cleveland has ever before presented.

The sum of $400,000 can be profitably expended during the fiscal year ending June 30, 1882, and if appropriated will be applied to continuing the construction of the breakwater. The importance of vigor-

ously pushing this work cannot be too fully stated. The commerce of Cleveland is large and important, and the necessity for increased facilities for it, as well as for a good harbor of refuge, is apparent to all who are interested in the commerce of the lakes. The work is now well advanced, and if a liberal appropriation is made during the next fiscal year the breakwater will be prolonged to such an extent as to provide a harbor of refuge from some of the severest autumn gales.

RÉSUMÉ.

An examination of the history of the improvement of the mouth of the Cuyahoga River shows that when operations were commenced in 1825 there was a long, low sand-bar where the river now empties into Lake Erie. In 1828 there was a channel with a depth of 6 feet; in 1833 the depth was 11 feet; and in 1839, when work was suspended, there was a good channel with a depth sufficient for the largest vessels navigating the lakes to enter at all times.

This depth was found to be maintained in 1844 and 1852. In 1864 the piers were found to be in a dilapidated condition, but the channel still presented a depth sufficient to admit vessels drawing 11 feet. In 1871 the depth was increased to 16 feet; in 1880 there is a good wide channel between the piers with a depth of from 16½ to 18 feet, and through the outer bar with a depth of from 17 to 19 feet at ordinary low-water.

It will thus be perceived that with an expenditure of about $350,000 the entrance to this very important harbor has been kept open for 55 years, and the depth in the channel gradually increased from zero in 1825 up to from 16½ to 18 feet in 1880.

Cleveland Harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the third order on shore, and a beacon on the outer end of each pier. The nearest work of defense is Fort Wayne, 110 miles distant. The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $197,706.11.

The value of the imports during that period was $46,313,580. The value of the exports during that period was $33,132,370. Twenty-six hundred and sixteen vessels with an aggregate tonnage of 1,130,021 tons entered, and 2,629 vessels with an aggregate tonnage of 1,142,756 tons cleared during the eleven months.

Abstracts of proposals and contracts and a money statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$184,917 01	
Amount appropriated by act approved June 14, 1880	125,000 00	
		$309,917 01
July 1, 1880, amount expended during fiscal year	84,280 61	
July 1, 1880, outstanding liabilities	1,494 84	
		85,775 45
July 1, 1880, amount available		224,141 56
Amount (estimated) required for completion of existing project		1,375,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		400,000 00

Abstract of proposals for constructing 1,000 *linear feet, more or less, of the new breakwater at Cleveland, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at* 11 *o'clock a. m. Tuesday, September* 16, 1879, *under advertisement of August* 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Hemlock timber and plank, 1,557,000 feet, b. m., per M feet, b. m.	White pine timber and plank, 652,968 feet, b. m., per M feet, b. m.	White oak timber and plank, 51,500 feet, b. m., per M feet, b. m.	1,824 treenails, per hundred.	Stone foundation, 2,340 cords, per cord.	Stone filling, 5,860 cords, per cord.	Stone riprap, 6,000 tons, per ton.	Totals.
1	Gustavus A. Karwiese, New York City, N. Y.	$14 87	$23 45	$24 50	$9 80	$11 90	$12 75	$13 80	....
		23, 152 59	15, 312 10	1, 261 75	178 75	27, 846 00	74, 715 00	82, 800 00	$225, 266 19
2	Hemenway & Hayes, Painesville, Ohio*	....	....	....	......	....	....	....	....
3	Thomas Keeler, Fulton, N. Y	20 00	23 00	35 00	10 00	4 25	4 60	1 50	....
		31, 140 00	15, 018 26	1, 802 50	182 40	9, 945 00	26, 956 00	9, 000 00	94, 044 16
4	Courtland D. Merry, Somerset, Pulaski County, Kentucky ..	19 00	20 00	23 50	3 00	4 85	4 85	1 09	....
		29, 583 00	13, 059 36	1, 210 25	54 72	11, 349 00	28, 421 00	6, 540 00	90, 217 33
5	John G. Moore, New York City, N. Y	22 50	24 50	30 00	10 00	4 50	4 50	1 50	....
		35, 032 50	15, 997 72	1, 545 00	182 40	10, 530 00	26, 370 00	9, 000 00	98, 657 62
6	John C. Williams, Cleveland, Ohio	17 84	21 50	23 00	4 50	4 65	4 65	1 40	....
		27, 776 88	14, 038 81	1, 184 50	82 08	10, 881 00	27, 249 00	8, 400 00	89, 612 27
7	Charles H. Strong, Cleveland, Ohio	17 00	26 75	23 50	6 00	4 65	4 65	1 15	....
		26, 469 00	17, 466 89	1, 210 25	109 44	10, 881 00	27, 249 00	6, 900 00	90, 285 58
8	Orsamus Sherwood and John Geissendorfer, Cleveland, Ohio† ...	16 50	24 00	24 00	5 00	4 10	4 10	1 60	....
		25, 690 50	15, 671 23	1, 236 00	91 20	9, 594 00	24, 026 00	9, 600 00	85, 908 93
9	Farris & Garfield, Painesville, Ohio	16 50	23 00	30 00	5 00	4 75	4 75	1 35	....
		25, 690 50	15, 018 26	1, 545 00	91 20	11, 115 00	27, 835 00	8, 100 00	89, 394 96

* Bid withdrawn before it was read.
† Contract awarded subject to the approval of the Chief of Engineers and of presentation of satisfactory bondsmen to the engineer in charge.

Abstract of proposals for constructing 1,000 *linear feet, more or less, of the new breakwater at Cleveland, Ohio, received and opened by Maj. John M. Wilson, Corps of Engigeers, at U. S. Engineer Office, Cleveland, Ohio, at* 11 *o'clock a. m., Tuesday, September* 16, 1879, *under advertisement of August* 14, 1879.

IRON.

No.	Name and address of bidder.	Approximate quantities.			Total.
		Bolts, screws, and washers, 840 (15,500 pounds) more or less.	Drift bolts, 24,000 (188,000 pounds) more or less.	Boat spike, 13,000 pounds, more or less.	
		Per pound.	*Per pound.*	*Per pound.*	
1	Geo. Worthington & Co., Cleveland, Ohio.*	$0 04 Washers, 5½ cts.; 13,820 pounds screw bolts, at 4 cents; 1,680 lbs. washers, at 5½ cents.	$0 03⅒	$0 03⅞	
		$645 20	5, 828 00	506 25	$6, 979 45
2	W. H. McCurdy, Cleveland, Ohio.	04½ Washers, 5 cts.; 1,382 lbs. screw bolts, at 4½ cts.; 1,680 lbs. washers, at 5 cents.	03½	03⅝	
		$705 90	6, 580 00	472 50	7, 758 40
3	Samuel A. Sague, Cleveland, Ohio.	04 Bolts and washers.	03¼	12-inch spike, 3½ cents; 9-inch spike, 3¾ cts.	
		$620 00	6, 110 00	$448 87	7, 178 87

* Contract awarded, subject to the approval of the Chief of Engineers.

Abstract of proposals for dredging 13,000 cubic yards, more or less, of mud, clay, sand, &c., from the channel at the entrance to Cleveland Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, March 2, 1880, under advertisement of January 28, 1880.

	Name of bidder.	Address of bidder.	Per cubic yard.	Remarks.
1	Elias Sims	Cleveland, Cuyahoga County, Ohio	35 cents.	Bid thrown out; no bond attached.
2	Jesse Sims	......do	32 cents.	
3	Patrick Smith	......do	30 cents.	Contract awarded subject to the approval of Chief of Engineers.

Abstract of contracts for breakwater at Cleveland (Ohio, improving and repairs of harbor,) in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Date of contracts.	Subject of contract.	White-pine timber and plank, per M feet, b. m.	Hemlock timber and plank, per M feet, b. m.	White-oak timber and plank, per M feet, b. m.	Treenails, per hundred.	Screw and washer bolts, per pound.
Franklin B. Colton, Philadelphia, Pa.	Oct. 29, 1878	Timber, workmanship, &c.	$17 20	$17 20	......	......	......
Charles H. Strong, Cleveland, Ohio.	June 19, 1879	....do	21 00	......	......	......	......
George Worthington & Co., Cleveland, Ohio.	Sept. 25, 1879	Iron, screws, and washer-bolts, &c.	......	......	......	......	$0 04
Sherwood & Giessendorfer, Cleveland, Ohio.	Sept. 29, 1879	Material and workmanship.	24 00	16 50	$24 00	$5 00	......
Patrick Smith, Cleveland, Ohio.	Mar. 8, 1880	Dredging, &c	......	......	......	......	......

Name and residence of contractor.	Date of contracts.	Subject of contract.	Wrought-iron washers, per pound.	Drift-bolts, per pound.	Boat-spike with large head, per pound.	Stone for foundation and filling, per cubic yard.	Foundation and filling stone, per cord of 128 cubic feet.	Stone for filling, per cord of 128 cubic feet.
Franklin B. Colton, Philadelphia, Pa.	Oct. 29, 1878	Timber, workmanship, &c.	......	......	......	$0 83	......	......
Charles H. Strong, Cleveland, Ohio.	June 19, 1879	....do	......	......	......	......	......	$3 80
George Worthington & Co., Cleveland, Ohio.	Sept. 25, 1879	Iron, screws, and wash-bolts, &c.	$0 05½	$0 03 1/10	$0 03¼	......	......	......
Sherwood & Giessendorfer, Cleveland, Ohio.	Sept. 29, 1879	Material and workmanship.	......	......	......	......	$4 10	......
Patrick Smith, Cleveland, Ohio.	Mar. 8, 1880	Dredging, &c	......	......	......	......	......	......

Abstract of contracts for breakwater at Cleveland, Ohio, &c.—Continued.

Name and residence of contractor.	Date of contracts.	Subject of contract.	Stone for riprap, per ton of 2,240 pounds.	Mud, clay, sand, &c., per cubic yard, in scows.	Large stone removed from channel and deposited on shore, each.	Contract completed and closed—
Franklin B. Colton, Philadelphia, Pa.	Oct. 29. 1878	Timber, workmanship, &c.	$1 17	......	....	December 13, 1879.
Charles H. Strong, Cleveland, Ohio.	June 19, 1879	....do	......	......	....	October 14, 1879.
George Worthington & Co., Cleveland, Ohio.	Sept. 25, 1879	Iron, screws, and wash-bolts, &c.	......	......	....	April 29, 1880.
Sherwood & Giessendorfer, Cleveland, Ohio.	Sept. 29, 1879	Material and workmanship, &c.	1 60	......	....	
Patrick Smith, Cleveland, Ohio.	Mar. 8, 1880	Dredging, &c......	......	$0 30	$5 00	May 27, 1880.

I I II.

IMPROVEMENT OF FAIRPORT HARBOR, OHIO.

HISTORY OF THE WORK.

Grand River rises in the northeastern part of the State of Ohio, and, flowing first north, then west, and then north, after a very circuitous course, empties into Lake Erie, at a point about midway between its eastern and western extremities.

1825.

The attention of the general government was first called to this harbor by the act of March 3, 1825, wherein an appropriation of $1,000 was made for its improvement.

The work was placed in charge of Capt. T. W. Maurice, of the Corps of Engineers, who made an examination of the harbor, and submitted a plan and estimate for its improvement.

Captain Maurice found an extensive sand-bar at the mouth of the river, extending east and west, and having a width of about 1,200 feet. At times this bar was dry and hard, and teams could be driven across, and again the river freshets were able to cut a channel 6 feet deep through it. Captain Maurice proposed to construct parallel piers, 200 feet apart, out to the depth of 10 feet in the lake, the west pier to be longer than the east, and to flare to the westward; and, by thus contracting the channel, to scour out the bar. The estimated cost of the work was $26,997.81.

1826.

The plan of improvement was approved, and contracts for materials were made.

An appropriation of $5,620 was made by the act of May 20, 1826.

1827.

Operations were commenced in the spring. During the year the east pier was nearly completed, and a portion of the west pier constructed; a great improvement was already noticed in the channel.

1828.

The east pier was prolonged 180 feet, and the west pier 390 feet; both piers were raised where settlement had occurred. The channel had deepened so as to admit any vessel navigating the lakes during the season of high-water. An appropriation of $9,135.11 was made by the act of May 19, 1828.

1829.

It was determined to prolong the piers out to 14 feet water; the west pier was extended 810 feet, but the superstructure was still unfinished on both piers. There was a depth of from 7½ to 8½ feet in the channel, which was then deemed sufficient for the largest vessels on the lake.

1830.

An appropriation of $5,563.18 was made by the act of April 23, 1830. From the failure to obtain an appropriation in 1829, the piers in their unfinished state were damaged considerably; they were repaired and prolonged.

1831.

An appropriation of $5,680 was made by the act of March 2, 1831, and was applied to raising the piers where settlement had occurred and prolonging them; at the close of the season they extended 1,440 linear feet into the lake, their outer ends resting in 12 feet water.

1832.

Major Maurice, who, up to this year, had been in charge of the harbor, died suddenly March 5, and the work was placed under the charge of Mr. J. D. Selden, as agent for the Engineer Department. An appropriation of $2,600 was made by the act of July 3, 1832, and was applied to filling the piers with stone and strengthening them.

1833.

By direction of the Chief of Engineers, an examination of the harbor was made in the summer of 1833 by Col. J. G. Totten, of the Corps of Engineers, who reported as follows:

> The works at the mouth of this river are two piers, separated about 200 feet, and running a nearly north course about 600 feet beyond the original shore into the lake; at this distance the eastern pier terminates, but the western turns a little to the westward, and proceeds 150 feet farther. Within the original line of the shore the western pier continues first south about 200 feet, and then southwest 308 feet to the left bank of the river. The eastern pier runs within the same line a nearly south course for about 400 feet, where it joins the private wharves. During the summer, before work was commenced, the mouth of the river was often entirely closed, while now there is a straight and free channel of at least 12 feet in depth.

The agent in charge reported that the piers should be strengthened by a riprap of brush and stone on each side, and for this purpose and for necessary repairs he asked for $18,350.

1834.

An appropriation of $10,000 was made by the act of June 23, 1834.

Operations during the season were confined to refilling with stone such portions of the pier as had settled.

1835.

Lieut. T. S. Brown, of the Corps of Engineers, was assigned to the charge of the harbor this year.

The accretion of sand around the west pier rendered its extension necessary, and it was prolonged 300 feet. A beacon light was erected on the east pier.

1836.

An appropriation of $6,000 was made by the act of July 7, 1836.

Lieutenant Brown was relieved by Capt. Henry Smith, of the United States Army. The piers had been seriously damaged during the winter of 1835–'36, a large amount of stone having been washed out of the cribs. Operations during the year were confined to the necessary repairs.

1837.

Operations during this season were confined to rebuilding and repairing damages sustained from storms of preceding years; securing the works, as far as possible, from similar disasters; preparing for a permanent superstructure to rest upon existing foundations; and riprapping with brush and stone the inner portions of the piers where there was a tendency to undermine.

1838.

An appropriation of $10,000 was made by the act of July 7, 1838. Operations were similar to those of the preceding year, and consisted in the repairs of damage done in the winter of 1836, and the further riprapping of the channel sides of the piers to prevent undermining.

The west beach had rapidly advanced and the sand was being driven around the outer end of the west pier. The prolongation of the west pier 300 feet was recommended, and an estimate of $38,874.66 was submitted for this and the permanent superstructure.

1839.

No appropriation was made this year.

The west pier now extended 555 feet beyond the shore line and the east pier 635 feet; since 1826, the shore line had advanced 1,180 feet on the west side and 440 feet on the east side; the depth in the channel was not less than 11 feet, the piers being about 200 feet apart; any vessel navigating the lakes could enter at any time without danger. A sand shoal had formed in advance of the piers, upon which there was only 8 feet water, but there was a channel on each side of it, between it and the heads of the piers, with a depth of 10 feet on the west side and 12 feet on the east.

No further appropriation was made nor work done until 1844.

1844, 1845.

An appropriation of $10,000 was made by the act of June 11, 1844, and the work placed in charge of Capt. A. Canfield, of the Corps of

Topographical Engineers. The piers were found to be in a dilapidated condition, but there was still a depth of 12 feet in the channel, although a bar was forming around the end of the west pier. The east pier was entirely rebuilt from the water level up, for a length of 643 feet, and 436 feet of the west pier was thoroughly repaired and strengthened. It was recommended that the west pier should be extended out to the depth of 14 feet to prevent the bar from getting across the channel and to thoroughly repair the remainder of the pier for a length of 1,225 feet. An estimate of $21,233.80 was submitted for this purpose, but no further appropriation was made until 1852.

1852.

An appropriation of $10,000 was made by the act of August 30, 1852. The piers were found to be in a dilapidated condition, and operations were commenced for their repair.

1853.

A complete survey was made of the harbor, which showed a depth of from 12 to 14 feet in the channel, but a sand-bar was gradually creeping around the end of the west pier.

The piers were rebuilt for a length of 1,250 linear feet, 280 feet of which was constructed from a depth of from 3 to 7 feet below the surface of the water; 290 linear feet was faced up and thoroughly repaired.

Capt. H. Stansbury, of the Corps of Topographical Engineers, was assigned to the charge of the harbor in April, 1853.

1854, 1855, 1856.

No work was done during these years, there being no funds available. Captain Stansbury submitted an estimate of $15,004.56 for prolonging the east pier.

1857.

Lieut. Col. J. D. Graham, of the Topographical Engineers, recommended this year that the east pier should be extended 416 feet, and that the west pier should be prolonged 320 feet parallel to the east, commencing at a point just beyond where the west pier began to flare. This plan had been previously suggested by the local agent, Mr. J. A. Potter (now brevet brigadier-general, United States Army, retired).

The estimated cost of this work was $41,498.94. No further appropriation was made nor work done until 1864.

1864.

In 1864 Col. T. J. Cram, of the Corps of Engineers, by direction of the Chief of Engineers, made an examination of the harbor. He reported the piers to be breached and to be in a most dilapidated condition, and the channel between them to be partially filled with sand. The outer bar had shoaled to such an extent that there was only 5 or 6 feet of water upon it, and the harbor, as far as the commerce of the lakes was concerned, was absolutely destroyed. He recommended that the piers should be thoroughly repaired and the channel dredged, at an estimated cost of $56,726. Colonel Cram objected to the flaring part of the west pier, and recommended that instead of rebuilding it new work should be constructed parallel to the east pier.

1865.

General Cram was directed to commence the necessary repairs of the piers, and an allotment of $24,453.24 for this purpose was made from the general appropriation of June 28, 1864. During the season the repair of both piers was pushed vigorously and a great deal accomplished. The recommendation in reference to the plan of the west pier was not approved, and the Chief of Engineers ordered that it should be rebuilt upon its old line. General Cram then recommended that the east pier should be prolonged in a direction parallel to the west pier, so as to contract the channel through the bar and scour it out. The estimated cost of this plan was $24,072.

1866.

An appropriation of $24,072 was made by the act of June 23, 1866. The repairs of the piers were pushed forward and at the close of the season both piers were in comparatively good order.

1867.

An appropriation of $60,000 was made by the act of March 2, 1867.

In January General Cram made an elaborate survey of the channel at the entrance to the river, carrying it out to a depth of 15 feet in the lake. This survey showed that the repairs made in 1865 and 1866 had already greatly benefited the channel. General Cram adhered to his original project of 1865, and recommended that the east pier should turn towards the west and run parallel to the west pier. While he preferred that both piers should have continued on straight lines and parallel from their commencement, still, as long as the west one had flared to the west, he thought the east one should run parallel to it.

General Cram's plan was not approved, and he was directed to prolong the east pier upon its present line. Work was at once commenced; 270 feet of cribwork was constructed and 120 feet sunk on the line of the pier. Repairs were made to both piers.

1868.

General Cram was relieved on May 28 by Maj. W. McFarland, of the Corps of Engineers. During the year the east pier was extended 180 feet, and the superstructure completed. As the cribs had settled the outer end was riprapped.

1869.

A survey made in May, 1869, showed that the prolongation of the east pier had driven the bar further out into the lake, and that the depth upon it had increased over 2 feet.

1870.

An examination of the harbor this year showed the piers to be in good condition, and that there was a channel between them and through the outer bar with a depth of 12 feet.

1871.

Some minor repairs were made to the piers this season. Major McFarland was relieved in April by Capt. and Bvt. Lieut. Col. Geo. L. Gillespie, of the Corps of Engineers.

added to each pier; the effect thus far was to cut a channel 4 feet deep through a dry sand-bar at the mouth, with a gradual increase of depth as far as the piers extended. It was anticipated that the spring freshets would assist materially in deepening the channel.

1828.

An appropriation of $2,400 was made by the act of May 19, 1828. Operations during the year were confined to raising, planking, and completing the piers built in 1827; the sand which originally covered the rock and gravel had been removed by the current, but there still remained a gravel-bar, which would probably require excavation. An estimate of $6,940.25 was submitted for continuing the improvement.

1829.

An appropriation of $6,940.25 was made by the act of March 3, 1829; the piers were this year extended into deeper water and the removal of the gravel-bar reported in 1828 was commenced.

1830.

The work of dredging the gravel-bar was continued this season with considerable success; a sand-bar commenced forming at the outer end of the piers and their prolongation was recommended, and an estimate of $7,013.66 was submitted for this purpose.

1831.

An appropriation of $7,015 was made by the act of March 2, 1831. During this season both piers were extended to their full extent across the outer bar, each being prolonged 150 feet and completed in a satisfactory manner. The dredging progressed well and the removal of a stratum of rock, which had been reached, was recommended.

1832.

An appropriation of $3,800 was made by the act of July 3, 1832.

Operations were commenced in the fall upon the ledge of rock across the channel; this ledge was about 200 feet long, and presented a depth of only 6½ feet upon it.

Major Maurice died suddenly in March, 1832, and the work was placed in charge of Mr. J. D. Selden, as agent for the Engineer Department.

1833.

An appropriation of $3,400 was made by the act of March 2, 1833. Operations were continued during the season, excavating the rock from the channel.
unfortunately the bed of rock encountered set limits to the effect of

By direction of the Chief of Engineers, an inspection of the harbor was made in the summer of 1833, by Col. J. G. Totten, of the Corps of Engineers. Colonel Totten reported that the piers were about 1,250 feet long, running nearly north into the lake, the channel between them varying from 100 to 145 feet; the effect of the works had been to scour out a channel and keep it open through what was formerly a dry sand-bar; the current; he reported that there was a depth of only 7 feet upon the rock, and recommended that the channel should be deepened to 10 feet,

and that both piers should be strengthened and extended 150 feet further into the lake.

1834.

An appropriation of $5,000 was made by the act of June 28, 1834. Operations were confined during the season to deepening the channel between the piers; 13,000 tons of stone and gravel were removed and a depth of 9 feet obtained.

1835, 1836.

Lieut. T. S. Brown, of the Corps of Engineers, was assigned to the charge of the harbor in 1835. An appropriation of $7,591 was made by the act of March 3, 1835, and was applied to prolonging the piers and excavating the rock; the west pier was extended 204 feet, carrying it out to a depth of 12 feet water. Great difficulty had been experienced in removing the rock by the chiseling process used, but by the close of 1836 a channel had been opened 215 feet long and 50 feet wide, with a full depth of 9 feet, and the greater part of the rock laid bare, by removing a large quantity of sand and gravel. A beacon light was erected in 1836.

Lieutenant Brown was relieved by Capt. H. Smith, of the Sixth Infantry, United States Army, in 1836. Captain Smith submitted an estimate of $29,919.44 for raising the piers, filling them with stone, excavating rock from the channel, and enlarging the inner harbor.

1837.

An appropriation of $8,000 was made by the act of March 3, 1837. The superstructure upon the portion of the west pier built in 1836 was completed, and the widening and deepening of the channel by blasting was continued. The effect of the blasting was far superior to that of the chisel heretofore used.

1838.

An appropriation of $8,000 was made by the act of July 7, 1838. Operations were continued during the season excavating rock from between the piers and repairing the piers. Three thousand eight hundred cubic feet of rock and 600 cubic yards of sand and gravel were removed from the channel; 152 linear feet of old crib-work, badly located, was removed and properly rebuilt; 550 feet of the outer part of the east pier and 200 feet of the west pier were raised from 2 to 4 feet and filled with stone.

1839.

Operations were confined during the season to excavating rock from between the piers. At this date the west pier projected 730 feet and the east pier 660 feet into the lake. The beach had advanced since 1827 607 feet on the west side and 455 feet on the east. At the beacon light the piers were 102 feet apart, and then they diverged; at the line of the beach they were 138 feet apart. A sand-bar had formed about 150 feet beyond the end of the west pier, having a depth of only 8 feet water upon it; between it and the piers there was a depth of 10½ feet; inside the pier-heads and between the piers there was a depth of from 11 to 12 feet, except through the rocky ledge, where therewas only 9½ feet.

1840, 1841, 1842, 1843.

The harbor during these years was in charge of Capt. W. G. Williams, of the Corps of Topographical Engineers, but no work was done for want of funds.

1844, 1845.

An appropriation of $5,000 was made by the act of June 1, 1844. The work was placed in charge of Capt. A. Canfield, of the Corps of Topographical Engineers, who at once made an examination of the harbor.

The piers were found to be in a dilapidated condition. The east pier was 1,239 feet long and the west pier 1,478 feet long. Repairs were promptly commenced, and by the close of the season of 1845 939 feet of the east pier was rebuilt from the water's edge, and 300 feet repaired; 524 feet of the west pier was rebuilt from the water's edge; 200 feet of the outer portion was in tolerably good condition, but the remainder was much dilapidated and required entire renewal.

Seven hundred and fifty linear feet of sand fence was constructed to prevent the sand from being driven into the channel.

An estimate of $37,193.87 was submitted for rebuilding old piers, extending them out to 14 feet water, and dredging the channel between them.

No further appropriation was made until 1852, and in the mean time the piers were rapidly falling into decay and the channel shoaling.

1852.

An appropriation of $10,000 was made by the act of August 30, 1852.

An examination of the harbor was made in October, and the piers were found to be in very bad condition; efforts were made to commence work that autumn, but stormy weather prevented.

1853.

In April, 1853, Capt. H. Stansbury, of the Corps of Topographical Engineers, was assigned to the charge of the work.

The piers were found to be quite dilapidated; there was a large breach in the east pier, and the outer portion of the west pier was entirely carried away.

During the season 670 linear feet of pier was constructed, 490 feet of which was rebuilt upon the old work from a depth of from 5 to 8 feet under water; 200 feet additional was thoroughly repaired.

A survey was make and a chart prepared, which showed that the channel had shoaled considerably at the outer end of the piers; an estimate was submitted for completing the repairs of the piers and extending them still further into the lake, so as to overcome the outer bar. No further appropriation was made until 1866.

1857.

Lieut. Col. J. D. Graham, of the Topographical Engineers, recommended the prolongation of the west pier 416 feet and the east pier 288 feet, and the dredging of the channel between them; he submitted an estimate of $38,013.56 for this purpose.

1865.

A survey of the harbor was made under the direction of Col. W. F. Raynolds, of the Corps of Engineers, in 1865; the piers were found to be in a very bad condition, and there was a depth of only about 7½ feet water at the entrance.

1866.

An appropriation of $24,708.82 was made by the act of June 23, 1866, and the work was placed in charge of Col. and Bvt. Maj. Gen T. J. Cram, of the Corps of Engineers.

General Cram immediately caused a careful examination to be made of the harbor, and on August 25 submitted a report with a plan and estimate for its improvement.

In reference to the east pier he stated that—

> The superstructure for 565 feet from the inner extremity of the pier out to the angle near the light-house, and from the angle out, one crib and part of another for 66 feet are gone, so that much repairing will be required.

He recommended that the following portion of this pier should be abandoned. In reference to the west pier he stated that 340 feet of the inner portion and the whole 190 feet of the outer, or flaring part, needed extensive repairs, but that even after these repairs were made there would be only 7½ feet water in the channel; he recommended that the piers should at once be put in order, and after this was done the remainder of the appropriation should be applied to dredging the channel. General Cram concluded his report with an earnest recommendation that the flaring parts of both piers should be abandoned, that the west pier should be prolonged 338 feet to the 12-feet curve in the lake upon the line of the inner portion, and that the east pier should be extended parallel to the west, 450 feet into the lake; he recommended that the channel between the piers should not be made wider than 104 feet, as he did not deem the current in the river sufficient to maintain a wider channel. The estimated cost of these suggested improvements was $57,710.28.

The recommendation for repairing the piers was approved and contracts made for materials in October, 1866.

1867.

An appropriation of $54,000 was made by the act of March, 2, 1867. Both piers were thoroughly repaired during the year. A complete survey was made of the harbor with borings down to the rock, and General Cram recommended that the channel between the old piers should be 12 feet deep, but only 60 feet wide, for fear of undermining the crib-work, but as the new extension of the piers would rest on rock, the channel could be 12 feet deep the entire width between them.

The plan adopted under the appropriation of 1867 was to abandon the flaring portion of the east pier, to extend that pier on the line of its inner portion out to a depth of 12 feet in the lake, to prolong the west pier from the outer end of the flare, parallel to the east pier, and to deepen the channel to 12 feet.

1868.

General Cram was relieved by Maj. W. McFarland, of the Corps of Engineers, in April, 1868. Operations were commenced upon the extension of the piers early in the spring, and by the close of the season the

east pier had been prolonged 360 feet and the west pier 240 feet, and the project, as far as extension of piers was concerned, was completed.

During the winter the piers settled somewhat irregularly, from 2 inches to 2 feet.

1869.

Contracts were made in June for deepening the channel at 30 cents per cubic yard for the removal of sand, and $1.20 per cubic yard for the removal of rock.

Operations were commenced in August and continued with considerable success until the close of the season; it was found necessary to resort to drilling and blasting in order to remove the rock.

1870.

Operations were resumed early in the spring deepening the channel, and by the last of June a cut, 60 feet wide, 1,000 feet long, and 12 feet deep at low-water, was completed, by removing the rock from 1 to 4 feet in depth. There were no funds available at the close of the fiscal year, and Major McFarland recommended that the channel through the rock should be widened so as to allow vessels to pass each other, and asked for $15,000 for this purpose.

1871.

An appropriation of $15,000 was made by the act of March, 1871. Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie in April, 1871.

Proposals were invited in May for widening the channel by removing 7,000 cubic yards of rock and the work was awarded at the rate of $2.25 per cubic yard.

Operations were commenced in July, and were satisfactorily prosecuted during the season; the channel through the rock was widened 30 feet and deepened to 13 feet by removing 4,505 cubic yards of solid rock and 3,436 cubic yards of loose rock and sand.

1872.

An appropriation of $15,000 was made by the act of June 10, 1872, and it was determined to increase the depth between the piers to 14 feet. A contract was made at $2.75 per cubic yard for removing solid rock, and 35 cents for loose rock, sand, gravel, &c.; under this contract 9,306 yards of rock and 4,212 yards of sand were removed; a large amount of blasted rock remained in the channel which could not be removed for want of funds.

1873.

An appropriation of $16,000 was made by the act of March 3, 1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, of the Corps of Engineers, in April, 1873.

A contract was made in June for removing solid rock at $2 per yard, loose rock at 50 cents per yard, and sand at 35 cents per yard. Colonel Harwood in his annual report for June 30 recommended the extension of the west pier 500 feet, the thorough repair of the old piers, and the completion of the channel to a depth of 14 feet; he asked for $80,000 for this purpose.

Operations were commenced in July deepening the channel and were

continued throughout the year, drilling and blasting being done from the ice during the winter. A channel 120 feet wide was opened through the outer bar.

1874.

Dredging was resumed early in the spring, and by the last of June a continuous channel 60 feet wide and 14 feet deep was completed from the harbor outward to the flare of the west pier, and 120 feet wide from thence to deep water in the lake. Although the outer bar was dredged to 14 feet in the fall of 1873, it shoaled again to 8 feet during the winter, and it was necessary to again dredge it in the spring of 1874. Colonel Harwood was relieved June 30 by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers. An appropriation of $35,000 was made by the act of June 23, 1874.

Contracts were made in August for extending the west pier 360 feet, constructing a catch-sand fence and dredging a channel through the outer bar. A catch-sand fence, 400 feet long was built just west of and parallel to the west pier to prevent the sand from blowing into the channel. Considerable repairs were made to both piers.

1875.

Work was resumed early in the spring; the west pier was prolonged 360 feet, and a channel 120 feet wide and 14 feet deep was opened through the outer bar by removing 10,873 cubic yards of sand. An appropriation of $25,000 was made by the act of March 3, 1875. Minor repairs were made to the west pier where necessary. A contract was made for widening and deepening the channel between the piers at $1.80 per cubic yard for solid rock, and 50 cents per yard for loose rock, sand, and gravel.

1876.

The work of drilling and blasting rock in the channel was carried on in February and March, and dredging was commenced in April; by the last of June 6,410 cubic yards of rock and 8,091 cubic yards of sand, &c., had been removed, and a channel 100 feet wide and 14 feet deep secured.

In October a severe gale seriously damaged the west pier and again piled up the sand on the outer bar, so as to prevent the entrance of large vessels; the pier was immediately repaired by hired labor and the channel again dredged through the outer bar. An appropriation of $5,000 was made by the act of August 14, 1876.

1877.

During this season the outer end of the east pier was rebuilt and a breach closed in the shore end of the west pier; the west pier was prolonged 40 feet by one crib and superstructure 24 feet wide sunk in water 17 feet deep.

1878.

Colonel Blunt was relieved by Maj. W. McFarland, of the Corps of Engineers, on January 1, 1878. An appropriation of $12,000 was made by the act of June 18, 1878.

Extensive repairs were made to the piers in September and October; a breach 40 feet wide in the west pier was closed and minor repairs made to various parts of that pier; 170 feet of the east pier was thoroughly repaired.

The bar at the entrance again gave trouble, and the channel was dredged by the Pennsylvania Railroad Company at their own expense. A contract was made in October for prolonging the west pier 200 feet. Major McFarland was relieved on December 28 by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers.

OPERATIONS IN 1879, PREVIOUS TO JULY 1.

An appropriation of $9,000 was made by the act of March 3, 1879.

Operations were resumed early in the spring under the contract of October, 1879, and by the last of June 80 linear feet of cribwork had been sunk on the prolongation of the east pier. The bar at the entrance having again shoaled, the work of dredging the channel through it was commenced about the middle of June, and by the end of that month 1,600 cubic yards of sand had been removed and a cut 40 feet wide and 17 feet deep completed.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

The opening of the fiscal year found operations in progress prolonging the east pier and dredging the channel at the entrance. Work was continued upon the extension of the east pier until the last of August, by which time 120 feet of cribwork had been sunk and 202 linear feet of superstructure completed to a height of 8 feet above the surface of the water.

In the construction of the 202 feet of pier built in 1879 the following materials were used:

138,600 feet, board measure, hemlock timber.
81,980 feet, board measure, pine timber.
9,853 feet, board measure, pine plank.
1,377 pounds screw bolts.
20,216 pounds drift bolts.
2,511 pounds spike.
520 cords of stone.

Extensive repairs were made to the west pier near its connection with the shore in July and August. Some timber had been carried away under water, and it was necessary to place some small cribs inside the old work and to thoroughly sheathe a portion of the pier with old plank. Minor repairs were made to both piers at various places where necessary.

ENTRANCE TO THE HARBOR.

An examination of the bar at the entrance to the harbor was made in May, 1879, and it was found to be shoaling. The work of dredging was commenced in June and continued until the last of July, by which time a channel 120 feet wide, with a depth of 17 feet, was completed by removing 3,740 cubic yards of sand; 2,140 cubic yards were removed after July 1. In August a shoal was noticed between the piers near their inner ends, and the channel was deepened at that place to 14½ feet, by removing 500 cubic yards of mud, sand, and gravel, and one large rock, upon which there was a depth of only 12½ feet.

The heavy gales in October and November again filled the channel through the outer bar. A survey was made in November and a chart prepared which developed the following facts:

There was a bar about 250 feet wide outside the piers and across the channel, upon which there was a least depth of 10 feet at low-water;

this bar was about 150 feet from the outer end of the piers, and after crossing it 15 feet water was found; the shoalest part of the bar covered the west half of the entrance, and the depth then increased to 13 feet on the prolongation of the line of the east pier; after entering the channel between the piers a depth of from 14½ to 16 feet could be carried up into the river.

By authority of the Chief of Engineers a dredge, with tug and two scows, was employed in March, 1880, at the rate of $7.50 per hour when working and nothing when idle from stress of weather, and the work of dredging through the outer bar was commenced in April and continued until the latter part of May; during this period a channel was opened 100 feet wide, with a depth of from 15 to 17 feet, by removing 5,849 cubic yards of sand at a cost of 16¼ cents per cubic yard.

In August proposals were invited for prolonging the east pier 200 feet, and the work was awarded in September, 1879, to Messrs. Hemmenway & Hayes, of Painesville, Ohio, the lowest bidders.

A contract was executed for the work in November, which required these parties to commence operations on April 1; they, however, did not begin until about the middle of the month, and since that time have shown such a lack of energy in the progress of the work that the engineer in charge has but little hope that they will complete the contract according to its terms.

During the present season it is proposed to prolong the east pier 200 feet, to dredge the channel through the outer bar, should it become necessary, as is probable, and to commence work upon the prolongation of the west pier.

An appropriation of $20,000 was made by the act of June 14, 1880.

As stated in my annual report for the last fiscal year, the drifting of the sand around the end of the west pier still continues to be a source of great trouble, and I again respectfully recommend that both piers be extended out to the depth of 16 feet in the lake; if this is done, the bar will be overcome for a time, and we will probably not be obliged to further extend the piers for several years.

I respectfully invite attention to the fact that while the piers at this harbor are about 160 feet apart at their beginning, the west pier at once inclines to the eastward, so that at a point 900 feet from their commencement they are only 100 feet apart; the west pier then flares to the westward for the next 200 feet, when the channel is again 160 feet wide, and it maintains this width to the outer end of the piers; the east pier maintains the same direction, about due north, throughout its entire length, while the narrowing of the channel is due to the change of direction in the west pier; the first 1,100 feet of the pier is old and the timbers badly decayed, and about 900 feet of it has fulfilled the object of its construction. I respectfully recommend that this 1,100 feet may be removed and the line of the west pier be made parallel to that of the east.

The estimated cost of this whole project of improvement will be as follows:

Prolonging west pier 400 feet, at $60	$24,000
Prolonging east pier 600 feet, at $60	36,000
Tearing away 1,100 feet of old pier, at $5	5,500
200 feet of pier, inner end of the west pier, at $40	8,000
1,000 linear feet of revetment, at $2.50	2,500
Dredging 20,000 yards, at 20 cents per yard	4,000
Contingencies 10 per cent	8,000
Total	88,000

Of this amount $20,000 has been appropriated by the act of June 14,

1880; $40,000 can be profitably expended during the next fiscal year, and if available will be applied to prolonging the piers and dredging.

The total amount appropriated for this harbor up to the close of the present fiscal year is $309,901.21, of which sum $281,653.67 has been expended.

The commerce of Ashtabula Harbor is rapidly increasing; there is now a large trade in coal, iron, limestone, lumber, &c.; it is the lake terminus of the Pennsylvania Railroad, and the Lake Shore and Michigan Southern Railroad have lately made extensive improvements, constructing docks, slips, &c.

RÉSUMÉ.

An examination of the history of this work will show that when operations were commenced, in 1826, the mouth of Ashtabula Creek was closed by a sand bar upon which there was a depth of only 2 feet water, and that where the present channel exists there was a dry sand-bar; under this bar at a depth of about 7 feet was solid rock.

By the year 1839, when operations were suspended, there was a good channel into the harbor with a depth of 9½ feet; but two small appropriations, amounting in all to $15,000, were made between the years 1838 and 1866, a period of twenty-eight years, and these were applied to the repairs of the piers; in 1866 the piers were found to be in a very dilapidated condition and the channel to have shoaled somewhat; by 1870 there was a channel 60 feet wide and 12 feet deep, rock having been removed from 1 to 4 feet deep, and by 1876 the channel was widened to 120 feet and deepened to 14 feet; at the close of the present fiscal year there was a channel about 100 feet wide and from 15 to 17 feet through the outer bar, while there was a good wide channel between the piers with a depth of from 14½ to 16 feet.

It will thus be seen that with an expenditure of about $281,000 the entrance to this important harbor has been kept open for fifty-four years, and the depth at the entrance gradually increased from zero to 15 feet, the last 8 feet gained being through solid rock.

Ashtabula Harbor is in the collection district of Cuyahoga, Ohio: there is a fixed white light, varied by flashes of the fifth order, on the west pier. Fort Porter, 120 miles distant, is the nearest work of defense.

The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $231.65. The value of the imports during this period was $2,024,125. The value of the exports during this period was $207,972. Two hundred and eighty-four vessels, with an aggregate tonnage of 182,625 tons, entered, and 295 vessels, with an aggregate tonnage of 183,380 tons, cleared during this period.

Abstracts of proposals and contracts and a financial statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$19,075 41	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$39,075 41
July 1, 1880, amount expended during fiscal year		10,827 87
July 1, 1880, amount available		28,247 54
Amount (estimated) required for completion of existing project		68,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		40,000 00

Abstract of proposals for constructing 200 linear feet, more or less, of pier at Ashtabula Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Bolts, screw and washer, 160 (2,760 pounds), more or less.	Drift-bolts, 3,765 (27,980 pounds), more or less.	Boat spike, 1,175 pounds, more or less.	Total.
		Per pound.	*Per pound.*	*Per pound.*	
1	Samuel A. Sague, Cleveland, Ohio.	$0 04¼	$0 03⅜	1,050 pounds 8-inch spike, at 3⅝cts. = $38.06; 125 pounds 10-inch spike, at 3¼ cts. = $4.06.	
		117 30	944 32	$42 12	$1, 103 74
2	Cleveland, Brown & Co., Cleveland, Ohio.	04. 44	03. 29	03. 94	
		122 54	920 54	46 30	1, 089 38

Contract awarded, subject to the approval of the Chief of Engineers.

Abstract of proposals for constructing 200 linear feet, more or less, of pier at Ashtabula Harbor, Ohio, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Hemlock timber and plank, 156,855 feet, b. m., per M feet.	White-pine timber and plank, 93,120 feet, b. m., per M feet.	Oak timber, 4,025 feet, b. m., per M feet.	300 treenails, per hundred.	Stone filling, 450 cords (128 cubic feet to the cord), per cord.	Totals.
1	Courtland D. Merry, Somerset, Pulaski County, Kentucky	$16 50	$19 00	$23 00	$3 00	$4 85	
		2, 588 11	1, 769 28	92 58	9 00	2, 182 50	$6. 641 47
2	Hemmenway & Hayes, Painesville, Ohio	15 00	19 00	19 00	2 00	4 50	
		2, 352 83	1, 769 28	76 47	6 00	2, 025 00	6, 229 58
3	C. Schulz, Cleveland, Ohio	24 90	24 90	28 00	3 00	6 10	
		3, 905 69	2, 318 69	112 70	9 00	2, 745 00	9, 091 08
4	George U. McKenzie and Alonzo F. McKenzie, Ashtabula, Ohio	15 00	21 00	25 00	2 25	5 00	
		2, 352 83	1, 955 52	100 62	6 75	2, 250 00	6, 665 72
5	Thomas Keeler, Fulton, N. Y.	20 00	25 00	40 00	10 00	5 00	
		3, 137 10	2, 328 00	161 00	30 00	2, 250 00	7, 906 10
6	Farris & Garfield, Painesville, Ohio	16 50	25 00	24 00	6 00	5 50	
		2, 588 11	2, 328 00	96 60	18 00	2, 475 00	7, 505 71

Contract awarded, subject to the approval of the Chief of Engineers.

[illegible] *Ohio, in force during fiscal year ending* [illegible], 18[illegible].

[illegible]	Date of contract.	Subject of contract.	White pine timber and plank, per M feet, b. m.	Hemlock timber and plank, per M feet, b. m.	Oak timber, per M feet b. m.	Treenails per 100.	Screw and wash bolts, per pound.	Drift bolts, per pound.	Boat spikes, per pound.	Stone filling, per cord of 128 cubic feet.
							Cents.	*Cents.*	*Cents.*	
[illegible] M. K[illegible], [illegible] Ohio	1879. [illegible]	[illegible]	$17 [illegible]	$24 [illegible]	.....	.....	.....	.....	.....	[illegible]
Cleveland Bros. & Co., Cleveland, Ohio	1879. Sept. 27	[illegible] and washer [illegible]	.....	.....	.....	.....	4.44	[illegible]	[illegible]	.....
[illegible] & H[illegible], P[illegible], Ohio	Nov. [illegible]	Materials and work [illegible]	[illegible]	17 00	$19 00	$2 00	.....	.....	.....	4 [illegible]

[illegible] August 30, 1879.

I I 13.

IMPROVEMENT OF CONNEAUT HARBOR, OHIO.

HISTORY OF THE WORK.

Conneaut Harbor lies about 30 miles to the westward of Erie, Pa., and 13 miles east of Ashtabula Harbor. The creek empties into Lake Erie a little to the west of the western boundary of Pennsylvania, and, although a narrow stream, presents a depth of about 15 feet water, after getting inside. Previous to the construction of the piers at the mouth of the creek it was not available for the entrance of vessels, the bar never having more than 2 feet water upon it and at times being entirely dry.

1829.

The attention of the general government was first called to this harbor by the act of Congress approved March 2, 1829, wherein an appropriation of $7,500 was made and the work was placed in charge of Capt. T. W. Maurice, of the Corps of Engineers.

Captain Maurice made a careful examination of the mouth of the river and submitted a plan and estimate for its improvement. He proposed to close the existing channel by a dam and by means of parallel piers running out from the shore to drive a straight channel through the sand-bar which, as usual on the south shore of Lake Erie, had formed across the mouth of the river. The piers were to be of ordinary crib-work filled with stone, and the estimated cost of the project of improvement was $20,001.65.

Operations were commenced in May, and by the close of the season the outlet of the creek was closed by a dam 180 feet long, and the under-water work of the piers for the new channel was completed for a length of 300 feet on the east side and 270 feet on the west.

1830.

An appropriation of $6,136.65 was made by the act of April 23, 1830. The west pier was prolonged 774 feet and the east pier 300 feet this

season. The dam at the former outlet had divided the current so that there was already a depth of 6 feet water in the channel, sufficient at that time for lake vessels of the second class.

1831.

An appropriation of $6,370 was made by the act of March 2, 1831. The depth of water continued to increase with the extension of the piers, which were this year carried still further into the lake, and in the autumn there was a depth of 8 feet in the channel.

1832.

An appropriation of $7,800 was made by the act of July 3, 1832. The piers were extended 180 feet into the lake.

Major Maurice died in March, 1832, and the charge of the harbor passed into the hands of Mr. J. D. Selden, as agent for the Engineer Department.

1833.

By direction of the Chief of Engineers, Col. J. G. Totten, of the Corps of Engineers, made a careful examination of the harbor in the summer of 1833 and reported as follows:

> The works for the improvement of the entrance to Conneaut Creek consist of two nearly parallel piers, which run first north for about 330 feet and then northwesterly about 800 feet into the lake; at this distance the piers diverge and continue 120 feet further, causing the channel, which is elsewhere about 100 feet wide, to be increased to 176 feet. Previous to the erection of these piers the mouth of the creek was often during a low stage of water entirely closed, being shut up by a dry sand bank. Now, excepting at one spot where there is a narrow gravel bank, with 8 feet water over it, the channel varies from 9 to 16 feet and remains equally deep at all seasons.

Colonel Totten recommended the construction of a permanent superstructure on the piers.

Two hundred and two feet of pier were built this season and some dredging done; the agent reported that the stone had settled considerably in the crib-work, and that a protection of brush and stone was required around the pier heads.

1834.

The small remainder of the previous appropriations was not sufficient to complete the work; the agent reported 760 cords of stone necessary to fill the piers, and recommended their prolongation 100 feet further, across a shoal that now gave trouble, just beyond their outer ends.

1835.

With the expenditure up to this date of $27,812.57 the work, as originally planned, was entirely completed and some dredging had been done. There was now a depth of 9 feet into the harbor, and it gave shelter during one month of this year to 26 vessels which sought refuge during a gale.

The superstructure of the work began to show signs of decay, and the sand had begun to work around the end of the west pier and form a bar across the entrance. Lieut. T. S. Brown, of the Corps of Engineers, was assigned to the charge of the harbor.

1836.

An appropriation of $2,500 was made by the act of June 2, 1836; this was applied to widening the creek, so that vessels, after entering, could turn around. An estimate of $8,000 was submitted for completing the "winding place" in the inner harbor.

Capt. H. Smith, of the United States Army, relieved Lieutenant Brown of the charge of the harbor this year.

1837.

An appropriation of $5,000 was made by the act of March 3, 1837. Captain Smith, who resigned his commission in the Army in November 1836, was assigned to duty as an agent in charge under the Engineer Department. He reported that this year 17,000 cubic yards of earth had been removed, by which a "winding place" has been formed, but recommended that, as many vessels sought the harbor as a place of refuge, it should be enlarged, and asked for $5,700 for this purpose; he also stated that the outer crib of the west pier had been undermined and had slid away a distance of 10 feet from the remainder of the work: to replace this by a larger pier head he asked for $8,032.

1838.

An appropriation of $8,000 was made by the act of July 7, 1838. Up to the date of the annual report of this year 7,193 cubic yards of earth had been removed from the inner basin, and it was proposed to continue work upon this until the appropriation was exhausted; the repairs of the west pier were carried on, and a new pier head framed and sunk.

1839.

But little was accomplished this year for want of funds. The dredging of the inner basin was continued, and a portion of the work projected in 1837, still remained to be done; the pier head sunk in 1838 was carried above water and completed.

The agent reported that the west pier extended 550 feet into the lake beyond the shore line, and the east pier, 640 feet; the beach had advanced since 1829, 390 feet on the west side, and 270 feet on the east side; the width of channel between the piers was 105 feet from their inner ends to the beacon; the piers then began to diverge, and were 165 feet apart at their outer ends; the least depth between the piers was 11 feet, but a bar existed just beyond them, and was evidently formed from the sand driven around the west pier; it was of fine sand, shifting in its character, and liable to vary under the influence of the current of the creek during freshets in the spring and of the gales from the lake in the autumn.

No further appropriations were made nor work done until 1844.

1844, 1845.

An appropriation of $5,000 was made by the act of June 11, 1844, and the charge of the harbor was assigned to Capt. A. Canfield, of the Corps of Topographical Engineers.

Captain Canfield made a careful examination of the harbor, and found the piers to be in a dilapidated condition, and that the channel had shoaled to about 8 feet. The work of repairs was commenced in the

autumn of 1844, and continued through the season of 1845; the east pier was entirely repaired, and 390 linear feet of it rebuilt from the water level; the west pier was in better condition than the east; 595 linear feet of it was repaired.

Captain Canfield recommended that the piers should be extended out to the depth of 14 feet by prolonging them 350 feet; he submitted an estimate of $35,712 for the extension and necessary repairs of the piers. No further appropriation was made nor work done until 1852.

1852, 1853, 1854, 1855.

An appropriation of $10,000 was made by the act of August 30, 1852.

In 1853 the work was placed in charge of Capt. H. Stansbury, of the Topographical Engineers; the piers were found to be in bad condition, and the channel to have shoaled considerably.

Operations were at once commenced, and during the seasons of 1853 and 1854, 890 feet of pier was entirely rebuilt upon the foundation of the old work, and 120 feet in addition thoroughly repaired.

Captain Stansbury stated in his annual report for 1855 that the piers as far as they extended were in good condition, and that the depth in the channel was now, never less than 9 feet, and generally 10 feet; he recommended the prolongation of the piers 150 feet into the lake.

1857.

Lieut. Col. J. D. Graham, of the Topographical Engineers, reported that the piers needed slight repairs; he recommended that they should be carried out to a depth of 12 feet in the lake, and that the channel should be dredged to that depth, and asked for $31,559.60 for this purpose. No further appropriation was made, nor any more work done until 1866.

1866.

An appropriation of $20,513.74 was made by the act of June 23, 1866, and the work placed in charge of Col. and Bvt. Maj. Gen. T. J. Cram, of the Corps of Engineers.

General Cram had an examination made of the harbor, and in September submitted a report in which he recommended the repair of the existing piers, the prolongation of the west pier 350 feet, and the dredging of a channel 115 feet wide, to a depth of 12 feet; his estimate of the cost of this work was $31,112.

General Cram strongly condemned the flare in the piers, believing it to have greatly facilitated the deposit at the mouth of the harbor. The depth at the entrance now varied from 8½ to 12 feet.

General Cram's project was approved and contracts were made for repairing and prolonging the piers.

1867.

An appropriation of $10,000 was made by the act of March 2, 1867.

Both piers were thoroughly repaired this season.

1868.

General Cram was relieved May 28 by Maj. Walter McFarland, of the Corps of Engineers.

In the spring of 1868 a heavy freshet in the creek occurred, and the channel between the piers being blocked by ice, the water formed a new

one, 150 feet wide, across the low beach at the inner end of the east pier; this was closed during the season by a crib-work 180 feet long; the prolongation of the west pier was commenced; a heavy gale in October carried away the two outer cribs sunk in September.

1869.

The west pier was extended 240 feet out to the 12-foot curve in the lake, and one crib was placed near the inner end of the east pier to more effectually close the breach that had occurred in 1868.

1870.

An appropriation of $6,000 was made by the act of July 11, 1870. The outer 60 feet of the west pier having settled about 5 feet during the winter, it was leveled up to a height of 7 feet above the water level.

1871.

Major McFarland was relieved by Capt. and Bvt. Lieut. Col. G. L. Gillespie, of the Corps of Engineers, in April, 1871. The east pier was prolonged 90 feet this season, and at the close of the year both piers were in good order.

1872, 1873.

At the close of the fiscal year ending June 30, Colonel Gillespie reported that both piers were in fair condition and that no further appropriations were necessary except for annual repairs.

An appropriation of $400 was made by the act of March 3, 1873, and was applied to riprapping the outer end of the west pier to prevent further settlement. Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood, Corps of Engineers, April, 1873.

1874, 1875.

Colonel Harwood was relieved by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers, June 30, 1874. An appropriation of $1,500 was made by the act of June 23, 1874, and one of $1,000 by the act of March 3, 1875.

These amounts were expended in repairing piers, filling with stone where settlement had occurred, and protecting the outer ends of the piers with piles.

1876, 1877, 1878.

No work was done in 1876; some slight repairs were made in 1877. Colonel Blunt was relieved by Maj. Walter McFarland, of the Corps of Engineers, January 1, 1878; the latter in his annual report stated that the project for the harbor was completed, that the depth in the channel was sufficient for the requirements of commerce, and that funds would be needed from time to time for repairs.

A heavy freshet in September made an extensive breach in the east pier. Major McFarland was relieved December 28 by Maj. and Bvt. Col. John M. Wilson, Corps of Engineers.

OPERATIONS DURING 1879 AND THE PRESENT FISCAL YEAR.

A careful examination was made of the harbor in January, 1879, and a breach of 330 feet was found in the east pier, while the superstructure for 150 feet on each side of the breach was in such bad condition as to

require entire renewal; the superstructure of the west pier was also in bad condition.

The depth in the middle of the channel between the piers varied from 16 feet at the inner end to 10½ feet at the outer end; no elaborate survey was made, as there were no funds available for that purpose.

A report was submitted in February, with an estimate of $26,092 for repairs; this estimate was renewed in the annual report for June 30, 1879, and the statement made that a less appropriation than $12,000 would do but little good, as, in order to save the harbor, the whole breach should be closed as soon as possible.

An appropriation of $6,000 was made by the act of June 14, 1880.

An examination of the harbor was again made in June, 1880; the east pier was in a most dilapidated condition, at least 500 feet requiring to be entirely rebuilt, and the superstructure requiring renewal upon 360 feet of the remainder; the inner portion of the west pier was decayed, dilapidated, and the superstructure breached.

After careful examination of the subject, I have to recommend the entire removal of the old east pier from where it commences to narrow the channel near the inner end, out to the portion built in 1871, and that it shall be replaced by a pile pier with a timber superstructure; this will give a wider channel at the inner end and the width would be very gradually increased to the outer end, instead of suddenly, as it is now; in addition to this the superstructure should be removed and replaced upon 790 feet of the west pier.

The depth in the channel varies from 10 feet at the outer end to 16 feet at the inner end of the piers, and after passing the latter, the depth of 15 feet can be maintained for some distance up the stream.

To prevent the channel at the entrance to the harbor from being filled up by sand and gravel coming in through the breach in the east pier and by materials brought down the river, and to restore the harbor to its former state of usefulness in accordance with the plan now presented, the following estimate is submitted:

FOR THE EAST PIER.

Removing 800 feet of old pier, at $5 per foot	$4,000 00
Constructing 800 feet of pile, at $25 per foot	20,000 00

FOR THE WEST PIER.

Removing 790 feet superstructure, at $10 per foot	7,900 00
Contingencies, 10 per cent	3,190 00
Total	35,090 00

Six thousand dollars is now available and $20,000 in addition can be profitably expended during the next fiscal year in renewing the piers.

No work will be attempted during the present fiscal year, as no effort should be made to close the breach until the whole of it can be closed, and the funds available are not sufficient for that purpose.

The total appropriation for this harbor up to the close of the present fiscal year is $112,629.39, of which amount $106,629.39 has been expended.

After the harbor is again put in order it will require an annual appropriation of $1,000 for repairs.

RÉSUMÉ.

A glance at the history of this harbor shows that when operations were commenced in 1829 for its improvement, the mouth of the stream was

this date the effect of the piers had been most satisfactory, a channel having been scoured out from 400 to 600 feet wide, with a depth of from 13 to 20 feet, where before there was only from 1½ to 3 feet water. The breach at the neck of the peninsula had greatly widened, so that where trees thickly stood when work began in 1824 there was now an opening nearly a mile wide and daily increasing, so that the whole peninsula was threatened.

Lieutenant Brown submitted a plan for partially closing the breach by cribwork, but leaving a channel 400 feet wide, so that vessels might enter or depart for either end of the bay; he also recommended deepening the eastern entrance, particularly within the bay, at the locality where the effect of the piers was not felt. His estimate was as follows:

Breakwater and channel piers at head of bay	$80,000
Deepening eastern entrance	17,000
Total	97,000

1836.

An appropriation of $15,000 was made by the act of July 2, 1836, for continuing work, and one of $122.80 for repairing the breach in the peninsula. Capt. H. Smith, of the Sixth Infantry, United States Army, was assigned to the charge of the harbor in August, under the direction of the Chief of Engineers. Operations were commenced early in August, continuing the repairs of the piers, and were prosecuted with vigor during the season. A crib-work, 140 feet long, was built around the government buildings on the pier for their protection. Work was commenced at the head of the peninsula, upon the plan submitted by Lieutenant Brown; 420 feet of crib-work breakwater was completed, strengthened by piling, and partially filled with stone; barracks were erected for workmen, machinery purchased, and arrangements made for a vigorous prosecution of the work.

1837.

An appropriation of $15,000 was made by the act of March 3, 1837. Operations were carried on throughout the season upon the breakwater at the breach in the neck of the peninsula, in connection with the new channel at that locality; 1,920 linear feet of this work was constructed, making its entire length 2,340 feet, or one-third of the whole breach. At the east end of the bay, 180 linear feet of the south breakwater was rebuilt at its junction with the main shore, where a breach had occurred.

The workshops, boarding houses, &c., at the west end, were enlarged and extended.

Up to this date there had been appropriated in all for this harbor $112,151.61, which had been expended as follows:

Work for opening channel at the east end of the bay	$84,210 24
Charge on account of steam dredge	2,189 31
Houses, shops, &c., at west end of bay	1,600 00
Construction of 2,340 feet of breakwater at west end of bay	22,349 56
Value of material on hand	1,802 50
Total	112,151 61

The progress thus far in partially closing the beach, preparatory to making a new channel at the head of the bay, was very satisfactory. A gale in November again cut a channel around the junction of the south breakwater with the main shore, at the eastern end of the bay.

1838.

An appropriation of $30,000 was made by the act of July 7, 1838. Capt. W. G. Williams, of the Topographical Engineers, was assigned to the charge of the harbor in September. Operations were continued during the year at both ends of the harbor; at the western extremity of the peninsula 570 linear feet of the crib-work of the breakwater north of the proposed channel piers was built, filled with stone, and partially rip-rapped, and 465 linear feet of the part south of the proposed entrance was partially completed. At the east end of the harbor the breakwater south of the channel was repaired and prolonged by a crib-work 300 feet long across a breach at its inner end where high water and heavy gales had cut out a channel from 4 to 16 feet deep; repairs were also made to the north breakwater and to the channel piers.

1839.

Operations were continued this year with the available balance of the appropriation of 1838, the breakwater at the neck of the peninsula on the south side of the proposed channel pier was prolonged 690 feet towards the shore, 150 feet of the portion built in 1838 was strengthened and filled with stone; 300 feet of crib-work was placed in position on the low ground at the northeast end of the work, north of the proposed entrance, to prevent the lake from cutting through at that point. At the east end of the bay 150 feet of the breakwater was repaired and 150 snags were removed from the harbor.

1840, 1841, 1842.

No appropriations were made during these three years, nor any work done. An examination made in 1841 showed that the lake was making rapid encroachments upon the peninsula north of the works, and threatened the destruction of the harbor. Captain Williams made an elaborate report, showing the necessity for immediate work. In 1842 the channel piers were reported to be badly injured, the breakwaters breached and going to pieces, the channel shoaling, and everything indicative of the gradual decay of the harbor.

1843.

The north pier of the eastern entrance was repaired and made secure this year by means of a small sum remaining from the appropriation of 1838; nothing more than this could be done, and the remainder of the works were left in a dilapidated condition.

1844.

An appropriation of $40,000 was made by the act of June 11, 1844. Up to this time the work of improvement had been as follows:

1. EAST END OF THE BAY.

From the main shore a breakwater 2,530 feet had been built to the south pier, which had been constructed 780 feet long. The north pier, which was about parallel and 360 feet from the south pier, was 1,240 feet long, and connected with the peninsula on the north by a breakwater 2,900 feet long; there was a depth of 18 feet between the piers,

but extensive shoals were forming, both inside and outside the entrance. The piers and breakwaters were in a dilapidated condition, requiring extensive repairs.

2. WEST END OF THE BAY.

The peninsula which originally joined the main shore at its western end had become an island; to prevent the destruction of the harbor an extensive line of crib-work had been built, and plans had been prepared, and work had progressed for the purpose of opening a new channel at the west end. Part of this crib-work had answered admirably for the purpose designed, but a portion left incomplete in 1839 for want of funds has been destroyed; the gap in the peninsula, which in 1835 was over a mile wide, had been reduced to a width of 3,000 feet with a depth of from 5 to 6 feet.

OPERATIONS IN 1844.

The erosion in the vicinity of the barracks for workmen threatened their destruction, and work was immediately commenced, renewing the part destroyed, and by constructing 470 feet of crib-work the buildings and shore in the vicinity were protected.

At the east end of the harbor the repair of the piers was vigorously pushed; the north breakwater was put in complete order, and north channel pier repaired, except a part of the superstructure and one breach 30 feet long.

1845.

Lieut. J. H. Simpson, of the Topographical Engineers, was assigned to the charge of the harbor in May, 1845. During the winter the old government dredge and scows had been raised from where they had been sunk, and by the latter part of June had been repaired. Operations were resumed early in the season. At the east end of the harbor the south channel pier was thoroughly repaired, except for a length of 130 feet; the south breakwater was entirely repaired except one breach of 280 feet near its junction with the main shore. The dredge was placed at work in the channel, and after more or less delay from breakage and necessary repairs, operations progressed well; 18,300 cubic yards of sand were removed, and a channel obtained 150 feet wide, with a least depth of 10 feet.

1846.

The breaches in the piers and breakwaters at the east end of the harbor, not closed in 1845, were repaired as far as funds would permit, and the works were left in comparatively good condition.

1847, 1848, 1849, 1850, 1851, 1852.

No work was done between the years 1846 and 1853. In the mean time the piers had become seriously dilapidated.

1852.

An appropriation of $30,000 was made by the act of August 30, 1852.

Maj. and Bvt. Col. William Turnbull, of the Topographical Engineers, was assigned to the charge of the harbor. An examination of it showed that the breach at the west end of the peninsula still existed, and that

the crib-work for its protection, constructed in previous years, had been almost destroyed.

The piers and breakwaters at the east entrance were in a dilapidated condition, and the entrance to the harbor had again shoaled.

1853.

Operations during this season were confined to the repairs of the piers and to efforts to prevent the erosion of the beach at the west end of the peninsula. The superstructure of 700 feet of the north pier was removed and rebuilt, and the pier thoroughly repaired for that distance. The shore of the peninsula was revetted to a considerable extent by brush and stone, with very satisfactory results.

1854.

The south channel pier was thoroughly repaired, and the attempt to protect the west end of the peninsula with brush and stone was continued with very great success.

1855.

A Board of Engineers was convened this year to examine and report upon the harbor. This Board, in order to give full value to the natural advantages of this splendid harbor, recommended as follows:

1st. The modification, repair, and extension of the present piers at the eastern entrance, to secure the proper depth of water between the lake and the bay or harbor within.

2d. The construction of channel piers to form a western entrance at or near the breach in Peninsula Point, and the security of the beach on either hand.

3d. The checking of the abrasion and restoring of the original water line of the peninsula, as far as this may be practicable.

The Board recommended that the eastern entrance should be widened to 500 feet by removing the old and building a new south pier, and to extend the north pier to 12 feet water in the lake. The estimated cost of the project was as follows:

Eastern entrance	$56,760 00
Western entrance	212,345 37
Total	269,105 37

Operations during the season were confined to efforts to close the breach and prevent further erosion of the peninsula at its west end by means of brush and stone.

1856.

The work of closing the breach and protecting the peninsula was continued during this season and met with flattering success with strong prospects of restoring the original water line.

1857.

In September Lieut. Col. J. D. Graham, of the Topographical Engineers, reported that considerable repairs were necessary to the works at the eastern end, and that the bars just inside and outside the piers had shoaled so much that it would be necessary to remove 17,000 cubic yards of sand from the inner and 10,000 yards from the outer bar in order to enable vessels drawing 9 feet water to enter.

Colonel Graham stated that, on account of the increase of prices of materials and labor, it would require $417,499.95 to carry out the plan of the Board of Engineers of 1855, and he asked for that amount in four annual appropriations of $104,374.99.

No further appropriations were made and no work of any kind carried on until 1864.

1864.

By direction of the Chief of Engineers, Col. T. J. Cram, of the Corps of Engineers, was assigned to the charge of this harbor in August, and in September made a careful examination of it. On November 12 he submitted an elaborate report with plans and estimate for its improvement; in this report he stated that the breach in the neck of the peninsula was entirely closed, and that this had been done by the United States; as Colonel Turnbull's last report in 1856, and Colonel Graham's in 1857, called for funds to close this breach it is probable that nature had completed the work which those officers had carried on so successfully, but which the want of funds prevented them from entirely accomplishing.

In describing the bay, Colonel Cram referred to the currents as follows:

The bay is a safe, commodious, and beautiful natural interior harbor, perfectly land-locked to all except easterly winds. During the westerly winds the water of the lake is driven towards the eastern half, and then the current sets strongly into the bay through the mouth, between the piers, and the exact reverse takes place during easterly winds.

Colonel Cram reported that the breakwaters constructed in former years had served their purpose, and although now dilapidated, needed no further attention; the north channel pier, which was 1,300 feet long, required extensive repairs, and the south channel pier was in bad condition. The outer bar had shoaled very much; the beach on the north side of the north pier had moved forward 280 feet since 1844, or at the rate of 13¾ feet per annum, and had now reached so near the outer end of the pier that the sand was being swept around it onto the outer bar, forcing the ship channel to the southward, until where there was 19 feet water in the straight channel in 1844, there was only 9 feet in 1864, and the ship channel at the entrance was narrow and crooked, and presented a depth of only 12 feet. Colonel Cram recommended that both piers should at once be repaired and a channel 12 feet deep dredged between them; that the north pier should be prolonged across the outer bar, and that a low place in the neck of the peninsula should be strengthened. His plans for repairs were approved in December, and an allotment of $15,000 was made from the general appropriation of June 28, 1864.

1865.

Operations were commenced early in the season, and by the middle of September the repairs recommended were completed.

In his annual report of 1865, General Cram asked for $15,126.90 for dredging a channel 13 feet deep at the entrance to the harbor, and for $21,835 for extending the north pier 500 feet into the lake.

1866.

An appropriation of $36,961 was made by the act of June 23, 1866, and General Cram was directed to apply it to the prolongation of

the north pier. A careful examination was made of the breakwaters connecting the channel piers with the shores on each side; both were found to be dilapidated, but as the beach had rapidly made out in front of the north breakwater, it was not deemed necessary to repair it; to thoroughly repair the channel piers the sum of $33,739 was asked for.

1867.

An appropriation of $25,000 was made by the act of March 2, 1867. Contracts were made in March for extending the north pier 500 feet and dredging the channel between the piers, and work was at once commenced. During the season a channel 200 feet wide and 14 feet deep was reported as dredged at the entrance to the harbor by removing 37,222 cubic yards of sand; the north pier was prolonged 498 feet. In October a violent gale caused a settlement and a partial overturning of 300 feet of the new work, injuring the structure to such a degree that a Board of Engineers was convened to determine the cause of the disaster and to recommend such steps as might be necessary for its repair.

1868.

An appropriation of $40,000 was made by the act of June 30, 1868.

In February General Cram submitted an elaborate report in which he stated that the damage done to the outer portion of the new work was due to the non-adherence by the contractor to the plans of the engineer. In March a Board of Engineers was convened, at Erie, to take into consideration the condition of the harbor; the Board made an elaborate report giving their opinion as to the cause of the careening of the outer portion of the north pier; they recommended the repair of 258 feet and the removal of 240 feet of the portion built in 1867, the prolongation of the pier to the depth of 14 feet in the lake, and the complete repair of the old piers and the south breakwater.

General Cram was relieved May 28, 1868, by Maj. W. McFarland, of the Corps of Engineers. Operations were commenced in June, dredging the channel through the inner bar, and repairing the pier; the channel was widened during the season to 100 feet with a depth of 13 feet at low-water by removing 27,000 cubic yards of sand, and 380 linear feet of the pier was riprapped, repaired, and strengthened.

1869.

An appropriation of $22,275 was made by the act of April 10, 1869. In his annual report on June 30, Major McFarland recommended the completion of the repairs of the north and south breakwaters and the deepening and widening of the channel through the inner bar. During the season 70 feet of the north pier and 40 feet of the south pier were rebuilt, and the channel through the inner bar was widened to 200 feet and deepened to 14 feet, by the removal of 41,331 cubic yards of sand.

1870.

Operations were resumed in April, widening the channel through the inner bar where the change of direction occurs, and 27,607 cubic yards of sand were removed from it during the season; the channel through the outer bar was deepened by removing 15,466 yards of sand, and at the close of the season there was a channel 200 feet wide and 14 feet deep through both bars.

The breakwater connecting the south pier with the south shore was thoroughly repaired. An appropriation of $20,000 was made by the act of July 11, 1870.

In October a Board of Engineers was convened at Erie to examine into the condition of the peninsula, and report what was necessary for its protection. The following is an abstract from their report:

The Board is of the opinion that the peninsula is in no immediate danger from the action of the lake waters, but as a measure of precaution against possible damage in case of a succession of seasons of unusually high-water accompanied with severe storms, it would be well to re-enforce those points where the 6-foot curve no longer exists; and as a further protection to this portion of the peninsula, the Board think that the growth of vegetation upon it should be encouraged to as great an extent as possible, and for this purpose it is believed that slips of silver poplar or beech, which grows and multiplies its roots and suckers with great rapidity, should be used extensively, and most especially at those points where vegetation is sparse.

1871.

An appropriation of $29,000 was made by the act of March 3, 1871. Major McFarland was relieved in April by Capt. and Bvt. Lieut. Col. George L. Gillespie, of the Corps of Engineers.

During the season the sunken part of the north pier was removed and that pier extended 120 feet; the north and south piers were thoroughly repaired, and the beach in front of the light-keeper's dwelling revetted where a breach was threatened; 8,777 cubic yards of sand were removed from the channel through the outer bar, and 40,617 yards from that through the inner bar.

1872.

An appropriation of $15,000 was made by the act of June 10, 1872. Operations were resumed early in the season, deepening and widening the channel through the inner bar; 35,229 cubic yards of sand were removed. The neck of the peninsula at the west end of the bay was strengthened by anchoring and picketing brush and weighting it with stone; 350 loads of brush and 187 cords of stone were used. Over 50,000 young trees and slips were planted for the protection of the peninsula.

1873.

Colonel Gillespie was relieved by Maj. and Bvt. Lieut. Col. F. Harwood in April, 1873.

Operations were continued during the season, deepening and widening the channel at the entrance, as far as available funds would admit; minor repairs were made to the piers at various points.

The fall and winter gales in 1873-'74 made alarming attacks upon the shore of the peninsula of Presqu'ile, seriously damaged the piers and threatened to breach the shore north of the north pier.

1874.

An appropriation of $20,000 was made by the act of June 23, 1874.

Colonel Harwood was relieved on June 30 by Lieut. Col. and Bvt. Col. C. E. Blunt, of the Corps of Engineers.

In August, a Board of Engineers was convened to devise a mode of protection for the north spit, at the entrance to the harbor, which spit was rapidly washing away; the Board recommended a construction of pile work and rubble stone; their recommendation was approved, and 1,472 linear feet of this character of work was built during the season

with excellent results. Dredging was carried on during the year when found necessary, and 10,000 yards of sand was removed from the inner and outer bars; the north pier was extensively repaired during the season.

A heavy gale in November breached the neck of the peninsula and steps were at once taken to repair the damage.

1875.

An appropriation of $80,000 was made by the act of March 3, 1875' Operations were commenced early in January repairing the breach in the neck of the peninsula by constructing a bulkhead of piles and heavy plank, strengthened with stone; the result was very satisfactory, the sand piling against the bulkhead and the beach rapidly forming; this form of protection was continued along the weather beach of the peninsula wherever there was danger of breaching. In his annual report for June 30, Colonel Blunt reported that the experiment of planting young trees had failed, as nearly all of them had been destroyed.

Extensive repairs were made to both piers during the season; the bay side of the north spit was strengthened by rebuilding 500 feet of the old north breakwater; the channel at the entrance was improved and deepened by removing 53,000 yards of sand from the inner and outer bars.

1876.

The construction of the bulkhead protection of the peninsula was continued throughout the season and 415 linear feet of the north channel pier was rebuilt from the water level. At the close of the fiscal year, Colonel Blunt made an elaborate report upon the harbor; he stated that 4,536 linear feet of the bulkhead protection for the peninsula had been constructed with excellent results, and that a recent examination showed the channel piers to be in poor condition and to need immediate attention; he recommended the prolongation of the south pier 870 feet and the completion of the channel at the entrance to a width of 300 feet and a depth of 15 feet. An appropriation of $40,000 was made by the act of August 14, 1876, $15,000 of which became available during this year.

An examination of the channel at the entrance showed that it had shoaled at least a foot, presenting in some places a depth of only 12 feet. Dredging was continued during the year, and about 20,000 cubic yards of sand was removed. Colonel Blunt was of the opinion that annual dredging would be required in order to keep the channel open to the desired depth.

1877.

Operations were continued during the season, prolonging the bulkhead for the protection of the peninsula, and at the close of the year the total length of the work was reported to be 6,547 feet.

Dredging was continued in the channel at the entrance, and 16,200 cubic yards of sand were removed; 300 feet of the north pier was rebuilt from the water line up, and the work protected on the channel side by a row of piles driven in contact with and bolted to the pier.

1878.

Colonel Blunt was relieved in January by Maj. W. McFarland, of the Corps of Engineers. An appropriation of $25,000 was made by the act of June 18, 1878.

Operations were commenced in May; a complete survey of the channel at the entrance and of the peninsula was made; 389 linear feet of the north pier was rebuilt from the water level up, and one crib, 16 feet long, placed on the west end to connect with the work of the previous season. In November a heavy gale damaged about 300 feet of the north pier, which was at once repaired.

The work of dredging at the entrance to the harbor was carried on from August until December, and the channel deepened and widened by removing 19,148 yards of sand.

Major McFarland was relieved December 28, 1878, by Maj. and Bvt. Col. John M. Wilson, of the Corps of Engineers.

OPERATIONS IN 1879, PREVIOUS TO JULY 1.

An appropriation of $25,000 was made by the act of March 3, 1879, but did not become available until August.

In March a contract was made for removing 130,000 cubic yards of sand from the channel at the entrance to the harbor, at 15 cents per cubic yard. Work was commenced in April and continued until the close of the fiscal year, June 30. During this period 27,237 cubic yards of sand were removed, and a channel 200 feet wide with a depth of from 15 to 16 feet obtained.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

The opening of the fiscal year found operations in progress under the contract of March, 1879, dredging the channel at the entrance to the harbor. Work was continued until November, when the contract was completed. During this period 102,763 cubic yards of sand were removed, and a channel obtained from the deep water of the lake to the deep water within the bay, with a width of 350 feet, and a depth of not less than 16 feet. This is the best channel ever obtained at the entrance to Erie Harbor.

In July ten large snags, which were dangerous to navigation, were removed from the bay.

An examination of the dredged channel was made in May, 1880, and it was found to have shoaled at some places on the side from 1 to 3 feet.

THE PENINSULA OF PRESQU'ILE.

A careful examination of the peninsula was made in June 1879; the protection fences were found to be in tolerably good condition, and the erosion of the weather beach did not appear to at all endanger the harbor; a few pile jetties were projected for the protection of the beach, and proposals for their construction were invited; the work was awarded in August to Mr. J. W. Williams, of Washington, D. C., the lowest bidder; Mr. Williams made various excuses for not commencing work and finally declined to enter into contract; on September 17, the honorable Secretary of War ordered the proposal of Mr. Williams to be canceled; as the season was then too far advanced to again advertise, no further steps were then taken towards constructing the jetties.

In November the line of the weather beach was surveyed, and but little change was found to have taken place during the year 1879.

The winter of 1879-'80 was an open one and the beach did not have the usual protection afforded by heavy ice; upon the opening of navi-

gation it was carefully examined, and the sea was found to have made serious inroads upon it; the protection fence was more or less badly damaged at various points, the stone washed away, piles broken off, and plank destroyed. It was determined to repair the fence and to construct a few pile jetties running out at right-angles to the shore; proposals were invited for this work in May, and the contract for it awarded in June to Messrs. McKenzie & Brother, of Ashtabula, Ohio.

THE PIERS.

The piers at Erie are in poor condition, the under-water work of the inner portion of the north pier being of inferior material, badly put together. Minor repairs were made to the north pier at various times during the year. Towards the close of the season of 1879, a vessel ran into the outer end of it, tearing away the superstructure and breaking the timbers down 3 feet under water; although the weather was stormy, the spray freezing upon the men while at work, the necessary repairs were promptly made.

In August proposals were invited for prolonging the south pier 600 linear feet, and in September the work was awarded to Messrs. Hemmenway & Hayes, of Painesville, Ohio, the lowest bidders, and contract was made in November, 1879. Operations should have been commenced under this contract on April 1, but the contractors gave various excuses for not commencing at the time, and up to the close of the fiscal year they had accomplished so little, and showed such a lack of vigor and energy in prosecuting the work, that the engineer in charge has but little hope that the contract will be completed in accordance with its terms.

The security of the harbor of Erie depends upon the peninsula of Presqu'ile; this peninsula has been from time to time seriously injured by the heavy gales from the lake; much work has heretofore been done for its protection and much will hereafter be required.

The present project provides for a depth of 16 feet at the entrance, and, in order to maintain this depth, requires the following work:

Extending north pier 800 feet, at $60 per foot	$48,000
Extending south pier 1,600 feet, at $50 per foot	80,000
Repairing north pier	5,000
Repairing south pier	4,000
Protecting peninsula of Presqu'ile	5,000
Contingencies 10 per cent	14,000
Total	156,000

Of this amount $45,000 has already been appropriated, leaving $111,000 still required; of this sum $50,000 can be profitably expended during the next fiscal year, and, if available, will be applied to prolonging the piers.

The total amount appropriated for this harbor up to the close of the present fiscal year is $616,367.23, of which amount $560,508.67 has been expended; about one-third of this sum was devoted to the project for an opening at the west end of the harbor, and for the protection of the peninsula.

During the present season it is proposed to prolong the south pier 600 feet, to strengthen and repair the north pier, to renew the superstructure upon 450 feet of the old south pier, and to construct pile jetties and repair the fence for the protection of the peninsula of Presqu'ile.

RÉSUMÉ.

The Bay of Presqu'ile is about 4½ miles long by 1½ miles broad, and its waters have their entrance and exit through a channel only 350 feet wide; at times, when the wind is blowing strongly from the eastward, the water in the east end of the lake is lower than that in the bay, and the current runs out with great velocity; a change of wind raises the east end of the lake, and to establish its level, the water, loaded with sand torn from the outer shore of the peninsula, rushes back with even greater velocity into the bay; the natural result is a bar at each end of the piers caused by the decrease of velocity after the current leaves their limits; bars will continue to form from time to time, and the shore-line on the north side of the north pier, to advance.

When the work of improvement was commenced at this harbor in 1824, the channel at the entrance was narrow and tortuous, with a depth of only 6 feet, and the depth on the present line of the channel was less than 2 feet; by 1827 vessels of ordinary draught were enabled to enter the harbor; by 1829 the depth at the entrance was from 7½ to 15 feet, and in 1833 there was a good channel with a depth of 12 feet from the lake into the bay, and this depth was maintained in 1839, when operations were suspended.

In 1844 the piers were found to be in a dilapidated condition; there was a depth of 18 feet between the piers, but shoals were forming at each end of them; in 1864 there was still a depth of 12 feet at the entrance, but the channel was narrow and crooked, and had been driven to the southward by the sand drifting around the north pier; in 1868 the channel was straightened, and the depth increased to 13 feet with a width of 100 feet, and the width and depth has been increased from time to time, more or less shoaling taking place in the mean while until the close of the year 1879, when there was a good channel, 350 feet wide and 16 feet deep, from the lake to the deep water of the bay.

It will thus be seen that with an expenditure of about $400,000 the entrance to this magnificent harbor has been kept open for fifty-five years, and the depth gradually increased from less than 2 to 16 feet.

Erie Harbor is in the collection district of Erie, Pennsylvania. It is lighted by seven lights: a fourth order coast light on the north shore of the peninsula, fixed white, varied by red flashes; a main harbor fixed white light of the third order, and five range lights of the sixth order to mark the channels. There is a fog-bell on the outer end of the west pier. The nearest work of defense is Fort Porter, 90 miles distant.

The amount of revenue collected during the eleven months from July 1, 1879, to May 31, 1880, was $3,683.88. The value of the foreign imports during this period was $6,949, and the value of the foreign exports was $12,578. Nine hundred and eighty-seven vessels with an aggregate tonnage of 708,604 tons entered, and 992 vessels with an aggregate tonnage of 695,083 tons cleared, during the eleven months.

Abstracts of proposals and contracts and a financial statement are transmitted herewith.

Money statement.

July 1, 1879, amount available	$53,510 30	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$78,510 30
July 1, 1880, amount expended during fiscal year		22,651 74
July 1, 1880, amount available		55,858 56
Amount (estimated) required for completion of existing project		111,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		50,000 00

Abstract of proposals for construction of jetties at Erie Harbor, Pennsylvania, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 12 o'clock noon, Saturday, August 9, 1879, under advertisement of July 9, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	350 piles, more or less, 7,170 linear feet, more or less, including driving.	38 logs, more or less, 1,235 linear feet, more or less, including the labor of hauling, putting in position, &c.	114 screw and washer bolts, more or less, 2,736 pounds, more or less, including the labor of putting them in the work.	Totals.
		Per linear foot.	*Per lin. ft.*	*Per pound.*	
1	Joseph Williams, Washington, D. C*	6,090 lin. ft., at 20 c. 1,080 lin. ft., at 18 c.	$0 30	$0 03½	$1, 878 66
2	James Dunlap and Jonas Bowers, Erie, Pa.	32	10	06	2, 582 06
3	W. W. Loomis, Erie, Pa.	50	25	06	4, 057 91

* 290 piles, more or less, 18 to 24 feet, driven in water from 1 to 8 feet depth, at 20 cents per linear foot; 60 piles, more or less, 18 feet long, driven on shore and in water from 6 inches to 3 feet in depth, at 18 cents per linear foot. Contract awarded; Mr. Williams afterwards declined to enter into contract, and, by direction of the Secretary of War, his proposal was canceled.

Abstract of proposals for constructing 600 linear feet, more or less, of pier at Erie Harbor, Pennsylvania, received and opened by Maj. John M. Wilson, Corps of Engineers, U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Hemlock timber and plank, 508,656 feet, b. m., per M feet.	White pine timber and plank, 217,926 feet, b. m., per M feet.	White oak snubbing-posts, 1,650 feet, b. m., per M feet.	1,312 treenails, per hundred.	Stone foundations and filling 1800 cords (128 cubic feet to the cord), per cord.	Total.
1	Charles H. Strong, Cleveland, Ohio	$16 50	$26 75	$36 00	$6 00	$5 85	
		8, 392 82	5, 829 52	59 40	78 72	10, 530 00	$24, 890 46
2	Farris & Garfield, Painesville, Ohio.	15 00	24 75	25 00	6 00	6 50	
		7, 629 84	5, 393 67	41 25	78 72	11, 700 00	24, 843 48
3	George U. McKenzie and Alonzo F. McKenzie, Ashtabula, Ohio.	14 25	22 00	25 00	2 25	5 25	
		7, 248 35	4, 794 37	41 25	29 52	9, 450 00	21, 563 49
4	Daniel M. Owen, New York, N. Y	18 00	24 50	40 00	10 00	6 00	
		9, 155 81	5, 339 19	66 00	131 20	10, 800 00	25, 492 20
5	Courtland D. Merry, Somerset, Pulaski County, Kentucky.	17 00	19 75	25 00	2 75	4 65	
		8, 647 15	4, 304 04	41 25	36 08	8, 370 00	21, 398 52
6	Hemmenway & Hayes, Painesville, Ohio.*	14 50	19 00	19 00	2 00	4 95	
		7, 375 51	4, 140 59	31 35	26 24	8, 910 00	20, 483 69
7	Gustavus A. Karwise, New York City, N. Y.	14 92	24 75	23 65	9 80	11 75	
		7, 589 15	5, 393 67	39 02	128 57	21, 150 00	34, 300 41
8	Thomas Keeler, Fulton, N. Y	18 00	25 00	40 00	10 00	4 25	
		9, 155 81	5, 448 15	66 00	131 20	7, 650 00	22, 451 16
9	W. W. Loomis, Erie Pa	17 50	30 00	30 00	10 00	9 62	
		8, 901 48	6, 537 78	49 50	131 20	17, 316 00	32, 935 96

* Contract awarded subject to approval of the Chief of Engineers.

Abstract of proposals for constructing 600 linear feet, more or less of pier at Erie Harbor, Pennsylvania, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, September 16, 1879, under advertisement of August 14, 1879.

[Approximate quantities.]

Number.	Name and address of bidder.	Bolts, screw and washer, 520 (9,500 pounds) more or less, per pound.	Drift bolts, 9,520 (76,000 pounds) more or less, per pound.	Boat spike, 3,100 pounds, more or less, per pound.	Totals.
1	Samuel A. Sague, Cleveland, Ohio...	$0 04¼ 403 75	$0 03⅜ 2, 565 00	2,600 lbs. 10" spike, at 3⅝ cents...... $94 25 500 lbs. 8" spike, at 3¼ cents...... 16 25 110 50	$3, 079 25
2	Cleveland, Brown & Co., Cleveland, Ohio*......	4 44/100 421 80	3 29/100 2, 500 40	3 94/100 122 14	3, 044 34

*Contract awarded subject to the approval of the Chief of Engineers.

Abstract of proposals for the construction of ten pile-jetties and the repair of the protection fence along the lake shore of the peninsula of Presq'ile, Erie Harbor, Pennsylvania, received and opened by Maj. John M. Wilson, Corps of Engineers, at U. S. Engineer Office, Cleveland, Ohio, at 11 o'clock a. m., Tuesday, June 22, 1880, under advertisement of May 20, 1880.

[Approximate quantities.]

No.	Name and address of bidders.	503 piles, more or less; 10,048 linear feet, more or less, including the driving and sawing off.	120 pine plank, more or less; 6,075 feet, b. m., more or less, including the labor of putting them in the work.	700 pounds, more or less, of 9" by ⅜" best quality wrought spike, including the labor of putting them in the work.	Totals.
		Per linear foot.	*Per M feet, b. m.*	*Per pound.*	
1	Jonas Bowers, Erie, Pa..........	48 cents..............	$28 00	6 cents........	$5, 035 14
2	Geo. W. & A. F. McKenzie, Ashtabula, Ohio*..............	28 cents..............	27 00	6 cents........	3, 019 46
3	W. W. Loomis, Erie, Pa.......	48 linear feet, at $1.50 per foot.......... 10,000 linear feet, at 48¾ cents per foot..	32 00	6 cents........	5, 183 40
4	David B. Salmon, Watkins, Schuyler County, New York..	35 cents..............	40 00	10 cents.......	3, 829 80

*Contract awarded subject to the approval of the Chief of Engineers.

Abstract of contracts for improving harbor at Erie, Pa., in force during fiscal year ending June 30, 1880.

Name and residence of contractor.	Dates of contracts.	Subject of contract.	Hemlock timber and plank, per M feet, board measure.	White pine timber and plank, per M feet, board measure.	White oak snubbing-posts, per M feet, board measure.	Treenails, per hundred.	Screw and washer bolts, per pound.	Drift-bolts, per pound.	Boat-spikes, per pound.	Stone for foundation and filling, per cord of 128 cubic feet.	Sand, &c., per cubic yard, in scows.
	1879.						*Cts.*	*Cts.*	*Cts.*		*Cts.*
O. J. Jennings, Dunkirk, N. Y.*	Mar. 29	(‡)	......	......	......	......	......	......	......	......	15
Cleveland, Brown & Co., Cleveland, Ohio†	Sept. 25	(§)	......	......	......	......	4.44	3.29	3.94	......	......
Hemenway & Hayes, Painesville, Ohio	Nov. 12	(‖)	$14 50	$19 00	$19 00	$2 00	......	......	......	$4 95	......

* Contract completed and closed November 6, 1879.
† Contract completed and closed May 1, 1880.
‡ Dredging.
§ Iron screws, bolts, &c.
‖ Materials and workmanship.

APPENDIX J J.

IMPROVEMENT OF THE HARBORS OF DUNKIRK AND BUFFALO, LAKE ERIE, AND OF HARBORS ON LAKE ONTARIO AND ON THE RIVER SAINT LAWRENCE.

REPORT OF MAJOR WALTER M'FARLAND, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., August 24, 1880.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1880, upon the river and harbor works in my charge.

Very respectfully, your obedient servant,

WALTER MCFARLAND,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

J J 1.

IMPROVEMENT OF DUNKIRK HARBOR, NEW YORK.

There being no appropriation available for this harbor during the past year, nothing has been done there, and the work remains in the same condition as at the close of the last fiscal year.

The length of the breakwater proposed in 1870 by the Board of Engineers, to whom the question of the improvement of this harbor was referred, was 2,860 feet, of which the part (560 feet long) beginning at the Dumb Beacon and running along the east side of the channel to the west end of the main arm of the breakwater was not to be built until it was shown to be necessary.

Of the main arm, which was to be 2,300 feet in length, 1,191 feet have been built, leaving 1,109 feet yet to be built. The port has not, however, developed as it was expected to do when the report of the Board of Engineers just referred to was made, and I agree with the opinion of the engineer who had charge of this work in 1875–'76–'77 that it is not expedient at present to extend the breakwater more than 510 feet farther, or to the angle referred to in Major Harwood's estimate for 1873, making its total length 1,700 feet.

The revised estimate for the completion of the whole work as recommended by the Board of Engineers was	$350,000 00
Of this amount there has been appropriated	98,000 00
Balance	252,000 00

The estimated cost of extending the breakwater only 510 feet, as here recommended, is $31,000, and the appropriation of $10,000 made June 14, 1880, will build 150 feet of this extension, leaving $21,000 yet to be appropriated for the construction of the remaining 360 feet.

The present project for the improvement of this harbor was adopted in 1870, the object being to form an artificial harbor by the construction of a breakwater in front of the town 2,860 feet long and nearly parallel with the shore, and to excavate a channel 13 feet deep. The channel has been excavated, and 1,191 feet of the breakwater have been built, at a cost of $88,000.

The appropriation of $21,000 asked for is to be applied to the extension of this breakwater.

Dunkirk Harbor, New York, lies in the collection district of Dunkirk. It is lighted by a third-order lake-coast light, fixed white, varied by white flashes; and by a sixth-order fixed white beacon-light at the channel or eastern end of the west pier. A dumb or day beacon marks the east side of the entrance to the channel. Fort Porter, at Buffalo, N. Y., 40 miles to the eastward, is the nearest work of defense.

The present condition of this harbor is shown by the map appended to my last year's report upon it.

The following statement of the commerce of the port is furnished from the records of the custom-house, through the courtesy of the collector of customs, for the fiscal year ending June 30, 1880:

Revenue collected from customs	$33 54
Value of imports	1,859 43
Value of exports	20 00
Number of vessels cleared	55
Their tonnage ... tons	12,688
Number of vessels entered	55
Their tonnage ... tons	12,688
Probable number of arrivals and departures of vessels which do not enter and clear	16

The chief articles of commerce at this port are lumber, limestone, and ice.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	252,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	21,000 00

J J 2.

IMPROVEMENT OF BUFFALO HARBOR, NEW YORK.

The contract with F. B. Colton dated October 29, 1878, for the extension of the breakwater southwardly 350 feet, by the sinking of seven cribs, each 50 by 38 feet, on a gravel and broken stone foundation laid in a trench in the bottom, was completed by the close of the working season; the time for its execution having been extended, on my recommendation, from August 31 to December 1, 1879.

During the progress of the work it was found necessary, as required by the approved plans, to dredge much deeper than had been provided for by the terms of the contract, in order to reach the rock substratum.

The depth of dredging required by the contract averaged 12 feet, but it was found necessary to go down 19 feet below the bottom in order to reach the hard substratum; the depth of water being about 30 feet, and the bottom of the trench being, therefore, about 49 feet below the surface of the lake.

A contract supplementary to Colton's contract of October 29, 1878, and designed to cover this additional work, was recommended by me and the recommendation was approved by the Chief of Engineers July 15, 1879.

The total length of the breakwater on the completion of Colton's contract was 3,426 feet.

Under date of October 29, 1879, proposals for the further extension of the Buffalo breakwater 500 feet under the appropriation of March 3, 1879, were called for by public advertisement, and the bids received were opened at the United States Engineer Office, Oswego, N. Y., at 10 a. m. on Saturday, November 29, 1879.

Two classes of bids were called for; one for iron, and one for workmanship and all material except iron.

There were but two bids for iron; the lowest of which, made by the Syracuse Iron Works, was informal, the sureties being officers of the company making the bid. The second bid, made by Frank Wilson, of Cleveland, was $1,200 higher. It was therefore recommended that both bids be rejected, and that proposals be again called for by circular, which recommendation was approved by the Chief of Engineers.

Of the bids for workmanship and all material except iron, the lowest was made by Gibson & Gager, of Buffalo, N. Y., who were found, on investigation, to be irresponsible. The next lowest bidder was D. E. Bailey, of Buffalo, who was known to be a capable and responsible contractor, and it was therefore recommended that the bid of Gibson & Gager be rejected and that of Bailey accepted.

A good deal of delay occurred in settling this question, which was ended finally by Gibson's refusing to take the work when called upon to furnish satisfactory bondsmen; thus confirming the opinion that had been formed as a consequence of the investigations that had been made, that his bid was offered for speculative purposes only, and should have been rejected. The award was finally made to Bailey, the contract being entered into January 27, 1880.

On the 30th of January of the present year circular letters under authority granted December 12, 1879 were sent out to dealers inviting sealed proposals for furnishing iron for the breakwater.

But two bids were received; the lowest, that of Pratt & Co., of Buffalo, was accepted, and the contract for furnishing iron was signed by them February 20, 1880.

This contract has been filled and the iron delivered to the contractor for workmanship.

Under the existing contract with D. E. Bailey, dated January 27, 1880, the following work had been done at the close of the fiscal year:

The foundation trench had been excavated to its full depth for a distance of 260 feet from the end of the breakwater, and partly filled with gravel.

Stone also had been thrown in for a distance of 100 feet, the foundation being completed for 50 feet.

The ten cribs contracted for were all under way; two of them were ready for sinking. Two dredges were at work, one digging the trench and one digging gravel.

The contract will probably be completed by the close of the working season of the present year.

Under the appropriation of $90,000 made by act of Congress approved June 14, 1880, sealed proposals for extending the breakwater 500 feet farther have been called for, and will be opened August 30, 1880.

MISCELLANEOUS.

In October, 1879, two breaks in the north side of the breakwater, produced by decay and storms, were repaired at the following cost:

Material	$[illegible]
Labor	141 [illegible]
Total	744 [illegible]

The steam rod-driver Terrapin, belonging to Buffalo Harbor, was put in repair and taken to Oswego, N. Y., for temporary use in making soundings.

SOUNDINGS AT INTERNATIONAL BRIDGE.

November 25, 1879, complaint was made by the Lumbermen's Association of Tonawanda that the International Bridge Company were dumping stone in the channel of the Niagara River at the head of the channel piers, which they feared would obstruct the navigation of the river. In the spring Mr. G. U. Mayo, assistant engineer, was instructed to make an examination of the matter. His report, made April 6, 1880, showed that at that time no obstructions were found to exist there.

The length which it was originally intended to give to the Buffalo Breakwater was 4,000 feet. Subsequently, however, a Board of Engineers, convened for the further discussion of the improvement of Buffalo Harbor, recommended, in a report dated August 6, 1874, to be found at page 569, Part II, Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1876, that this breakwater be extended to a length of 7,600 feet; that a pile-pier 10 feet wide be run from a point in the shore line opposite the head of the Blackwell Canal, perpendicularly to the shore, until it reached the 16-foot curve, a distance of about 1,000 feet; and that from its outer end a cribwork structure be built toward the proposed south end of the outer breakwater, a distance of about 3,100 feet; leaving a channel between its outer end and the south end of the breakwater of about 150 feet.

The pile work is designated as the south pile-pier to distinguish it from the south pier, which lies at the south side of the mouth of Buffalo Creek.

The estimated cost of the work proposed by this Board was $2,000,000. This scheme was approved by the Secretary of War October 3, 1874.

	Feet
Length of breakwater ordered	7,600
Now built	3,426
Remaining to be built	4,174
Length of south pile-pier ordered	1,000
Now built	870
Remaining to be built	130
Length of cribwork continuation ordered, none built	3,100

The total estimated cost of this work was $2,000,000. Of this there was appropriated:

By act of March 3, 1875	$100,000
By act of August 14, 1876	85,000
By act of June 18, 1878	80,000
By act of March 3, 1879	100,000
By act of June 14, 1880	90,000
Total	455,000
Balance yet to be appropriated	1,545,000

It will be remembered that in my last annual report I stated that the Delaware, Lackawanna and Western Railroad Company had taken possession of the north United States pier at Buffalo, which had been in possession and occupancy of the United States for over 50 years—since 1826—and were gradually excluding us from its use; and that the question had been referred to the Department of Justice for investigation and action, but that nothing apparently had yet been accomplished, while the railroad company continued their encroachment.

In October, 1879, this matter came to a crisis. On the 1st instant, Mr. Mayo, my assistant at Buffalo, reported to me that he had been notified by the agent of the railroad company that in about two weeks they would remove our engineer boat-house from the north pier. I wrote immediately to the Chief of Engineers, and to the United States district attorney for the northern district of New York, reporting the threatened action, and asking for instructions. In answer, I received from the Office of the Chief of Engineers a letter inclosing the opinion and advice of the Attorney-General of the United States, "that the Officer of Engineers be instructed to retain possession and compel the railroad company to legal proceedings," and this was approved by the Secretary of War.

On the 13th of October, I telegraphed Mr. Mayo as follows:

Secretary of War directs that boat-house shall be held in possession. See that it is secured and watched.

In answer to further inquiry as to what actual steps should be taken by me in the event of the railroad company's refusing to regard my notice to them to stop their encroachments upon the United States property, which refusal seemed highly probable, the following instructions and orders were sent to me:

ATTORNEY-GENERAL TO SECRETARY OF WAR.

DEPARTMENT OF JUSTICE,
Washington, November 7, 1879.

SIR: I have the honor to acknowledge the receipt of your letter of the 4th instant addressed to the Attorney-General, and the inclosure therewith, to wit, a letter of the 23d ultimo, written by Walter McFarland, Major of Engineers, to Brig. Gen. H. G. Wright, Chief of Engineers, relative to the interference by the Delaware, Lackawanna and Western Railroad Company, or the Delaware and Hudson Canal Company, with the possession by the United States of the north United States pier at Buffalo, N. Y.

Major McFarland states that the government has been in possession of the premises for fifty years, and that "the pier and United States boat-house at its outer end have been in constant use and occupation by the United States through its employés."

Such being the fact, it is very clear that the agent of the United States in charge should hold possession of the pier and of all the property appurtenant thereto, which the government has for so long a period occupied.

If the railway company or canal company attempt to meddle with this possession, Major McFarland should oppose such resistance and so much force as is necessary to retain it.

He does not need the services of special legal counsel, but only to be instructed to hold every inch of ground to which the possession of the government for so long a period gives it a title, and to be furnished with such force as is necessary to enable him to do so.

I must therefore decline to comply with the suggestion of Major McFarland that special counsel be employed in this case.

I have, however, again called the attention of the United States attorney of the district to the matter.

Very respectfully, your obedient servant,

S. F. PHILLIPS,
Acting Attorney-General.

Hon. GEORGE W. MCCRARY,
Secretary of War.

[First indorsement.]

Respectfully returned to the Chief of Engineers, who will direct the Engineer Officer to maintain his possession in accordance with the opinion of the Attorney-General.
By order of the Secretary of War.

JOHN TWEEDALE,
Acting Chief Clerk.

WAR DEPARTMENT,
November 11, 1879.

CHIEF OF ENGINEERS TO MAJOR WALTER M'FARLAND, CORPS OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS.
Washington, D. C., November 13, 1879.

SIR: The inclosed copy of a letter from the Department of Justice of the 7th November in relation to the interference by the Delaware, Lackawanna and Western Railroad Company, or the Delaware and Hudson Canal Company, with the possession by the United States of the north United States pier at Buffalo, with the indorsement of the Secretary of War of the 11th instant returning same to this office, is furnished for your information and guidance.

You will, in compliance with the instructions of the Secretary of War, maintain possession of the pier in accordance with the opinion of the Attorney-General.

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

JOHN G. PARKE.
Lieutenant Colonel of Engineers,
Brt. Maj. Gen., U. S. A.

Maj. W. McFARLAND,
Corps of Engineers, U. S. A.

P. S.—It is suggested that you notify the Delaware, Lackawanna and Western Railway Company of the opinion of the Department of Justice and the instructions of the Secretary of War thereon.

On the 13th of November, the United States district attorney for the northern district of New York, the Hon. Martin I. Townsend, made a report upon this matter to the Department of Justice, an official copy of which was furnished me through the War Department, and which concluded as follows:

I do not hesitate to advise the War Department to place men with arms in their hands—soldiers from the arsenal—to protect the pier.

The government is in possession, and although its rights are liable to adjudication in court, the public property should be efficiently protected until a court intervenes.

On the 19th of November I telegraphed my assistant engineer at Buffalo, Mr. Mayo, as follows:

Notify the agent of the railroad that the Secretary of War directs that the north pier is to be held by the United States by force. Then be present with witnesses and forbid any attempt to work upon it. If the force against you is too great, report it at once, making it plain to them that you are prevented by force from doing the duty required of you.

The same evening, November 19, I received the following telegram from Mr. Mayo:

Railroad company will cut communication with boat-house, leaving water on all sides. Shall I enjoin them to-morrow? Attorney Townsend's letter to me yesterday says do nothing more at present.

MAYO.

Upon receipt of this, I sent the following telegram to the Chief of Engineers:

OSWEGO, *November* 19, 1879.

Railroad company mean to cut United States Pier at Buffalo in two to-morrow. I have no means of enforcing order of Secretary of War to keep possession of it. Will he order military company at Fort Porter to guard it?

McFARLAND.

And in answer received the following message:

WASHINGTON, *November* 20, 1879.

The following has been telegraphed commanding officer at Fort Porter by Adjutant-General:

"The Secretary of War directs that you immediately send a sufficient guard to keep possession of the pier at Buffalo to execute orders given to Major McFarland, United States Engineers."

PARKE,
Engineers.

A dispatch was sent immediately to the commanding officer at Fort Porter, stating what instructions I had received in the matter from the Secretary of War; and the same day the pier was quietly taken possession of by an armed guard from Fort Porter, the railroad company stopping work upon it on the demand of the officer in command.

On the 25th of November, and subsequently on the 8th of December, the railroad company made application through its counsel to the honorable Secretary of War for permission to continue their work upon the north United States pier, on the ground that they believed that they possessed a rightful title to it, and that it would put them to a good deal of inconvenience and expense if they were prevented from carrying out the work which they had already contracted to have done, offering at the same time to furnish such guarantees as might be necessary to prevent anything done in this behalf from affecting the then present legal status.

These applications and the proceedings that were taken under them are explained by the following letters and indorsements:

DELAWARE, LACKAWANNA AND WESTERN RAILROAD COMPANY TO THE SECRETARY OF WAR.

THE ARLINGTON,
Washington, D. C., November 26, 1879.

SIR: In the matter of the controversey between the government and the Delaware, Lackawanna and Western Railroad Company over the north pier of Buffalo Harbor, we desire to submit the following:

First. The railroad company claims, and believes it will at the proper time be able to satisfy the government authorities, that it is the owner in fee, by regular, proper title, of the land on which the pier rests.

Second. That the government never obtained any title, but about the year 1826 constructed its pier, paying no attention to the question of title.

Third. That the railroad company being the owner of the water lots north of and adjoining the pier, have lately filled these lots for the purpose of utilizing them for coal purposes.

Fourth. That believing itself to be the owner of the pier it made examination of it and found that it was defective in that it rested simply on the earth bottom and had become quite dilapidated, tilted over, &c., and that, owing to its construction, it had been impossible to give sufficient depth of water alongside for purposes of navigation (the depth extending out (*sic*) about 20 feet into Buffalo Creek, alongside, being only about 10 feet), and they therefore set about taking up this pier and putting down *on the same line* a new pier, going down 18 feet to the bed rock, and dredging alongside so as to give *a depth of water of* 16 *feet;* this along the length of the company's entire line, to wit, 720$\frac{2}{10}$ feet.

In the prosecution of this undertaking they *have removed* 500 *feet* of the old pier, have constructed to the surface of the water 315 *feet*, and were engaged with a force of more than 100 men and two dredges in the work, expecting to complete it this fall (having commenced October 2, 1879), when, on the 20th instant, they were stopped by the government officials, who took possession by the Federal soldiers.

Fifth. Waiving the question of legal rights for the present, certain practical considerations make it desirable that the work be continued.

In the first place, should it not be it is probable that by the storms of the coming season the earth will be washed into the harbor and the spring navigation obstructed.

Secondly. The company will sustain great pecuniary loss, and all this will be without any benefit to anybody.

If we are permitted to go on, a new pier in the place of the old one, much better and more permanent, will be put on the site of the old one before the winter fairly sets in, the damages to future navigation will be guarded against, and the harbor much improved.

We respectfully suggest that such immediate examination be given by the department of these matters (not including questions of title) as will satisfy it as to the facts, and that orders may be given that the railroad company be not further interfered with in the prosecution of this work, the company meantime executing such instruments as may be satisfactory to you, guaranteeing that whatever shall be done in this behalf shall not in any way affect the legal *status*.

I am, sir, very respectfully, your obedient servant,

SHERMAN S. ROGERS,
Counsel for Delaware, Lackawanna and Western Railroad Company.

Hon. GEORGE W. MCCRARY,
Secretary of War.

[First indorsement.]

WAR DEPARTMENT, *November* 26, 1879.

Respectfully referred to the Acting Chief of Engineers for early report.

GEORGE W. MCCRARY,
Secretary of War.

[Second indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
November 26, 1879.

Respectfully referred to Maj. Walter McFarland, Corps of Engineers, for his information and with request that he will make the examination asked for without delay and report his views fully thereon.

It will be seen that early action is desired by the Secretary of War.

JOHN G. PARKE,
Acting Chief of Engineers.

[Third indorsement.]

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., November 28, 1879.

Respectfully returned to the Chief of Engineers.

The statement of the counsel for the Delaware, Lackawanna and Western Railroad Company is a fair one with this exception, that the troops were not used to compel the company to stop work. They stopped work when the demand was made by my assistant, under telegraphic orders from me containing the decision of the honorable Secretary of War to use force if necessary. *After* they had stopped work, a guard was placed over the pier in dispute, with orders to permit no work to be done upon it. In regard to the permission asked to continue work without prejudice to the title of the United States, I have to say that I think it would be to the interest of the public, as well as of both parties to the controversy, to allow this so far as the restoration of the work already pulled down by them is concerned, but no farther. If the title is eventually shown to be in the United States, then the railroad company would have to rebuild this work or pay for it, and if it is shown to be in the railroad company, then it will be well to have the claim for damages which they will make against the United States as low as possible.

But whatever work is done under these circumstances should first be submitted to and approved by the Chief of Engineers. My recommendation then, is, that the company be allowed to continue the reconstruction of the 500 feet of the north pier that they have pulled down, first submitting their plans to the Chief of Engineers for approval and guaranteeing that they will disturb no other part of that pier, *nor interrupt* land communication with the boat-house at its western end, until this controversy is settled, and that the permission so granted them shall not be used or construed in any way to the prejudice of the title of the United States to the premises.

WALTER MCFARLAND,
Major of Engineers.

[Fourth indorsement.]

OFFICE OF THE CHIEF OF ENGINEERS,
December 1, 1879.

Respectfully returned to the honorable the Secretary of War, inviting attention to the foregoing indorsement (third) of Maj. Walter McFarland, Corps of Engineers, whose views are concurred in.

It is recommended, therefore, that the Delaware, Lackawanna and Western Rail-

road Company be allowed to continue the reconstruction of the 500 feet of the north pier that they have pulled down, first submitting their plans for approval and guaranteeing to the United States that they will disturb no other part of that pier or interrupt land communication with the boat-house at its western end until this controversy is settled: and that the permission so granted shall not be used or construed in any way to the prejudice of the title of the United States to the premises.

JOHN G. PARKE,
Acting Chief of Engineers.

[Fifth indorsement.]

The views and recommendations of the Chief of Engineers are approved. But the stipulation which is to be agreed upon between the United States and the railway company should be submitted to the United States district attorney for his approval.

The Chief of Engineers will instruct Major McFarland accordingly.

By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

WAR DEPARTMENT, *December* 3, 1879.

DELAWARE, LACKAWANNA AND WESTERN RAILROAD COMPANY TO THE SECRETARY OF WAR.

WASHINGTON, D. C., *December* 8, 1879.

SIR: Referring to my communication of November 26 in relation to the controversy about the old North Pier of Buffalo Harbor, I desire to say that I learn from conversation with Major McFarland that the length of pier heretofore removed by the Delaware, Lackawanna and Western Railroad Company is about 613 feet, instead of 500 as stated by me in my letter of November 26. The error in statement arose from a want of correct information on the subject.

What I desire now to say is this: The whole length of pier which the company desires to build is 720 feet. It would not seem necessary, in order to protect any public interest that while the company is permitted to construct its pier over the 613 feet it should be prevented from doing so over the other 107 feet. The contract which the company has made calls for the construction of the entire 720 feet, and I earnestly request that the company be permitted to go [on] and complete it, submitting its plans to the Department of Engineers and giving its stipulation that *the entire new pier shall, so far as the legal rights of the government and the company are concerned, stand precisely as the old pier did, and that the rights of the government shall not be prejudiced by anything done or left undone by it before the completion thereof.*

I understand it to be desirable that conveniences be provided at or near the pier for a boat-house and landing for the government officers and men engaged in building the Buffalo Breakwater and other improvements of the harbor. The company will gladly furnish whatever conveniences of this kind may be desired. I am very desirous of returning home as early as possible, and the present favorable weather would greatly assist the speedy completion of the work.

May I ask the submission of this matter to the Engineer Department for further report, or such other action in the premises as shall seem to you to be proper?

I am, sir, with great respect, your obedient servant.

SHERMAN S. ROGERS,
For said Company.

[First indorsement.]

Respectfully referred to the Acting Chief of Engineers for early report.

GEORGE W. MCCRARY,
Secretary of War.

DECEMBER 8, 1879.

[Second indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
December 8, 1879.

Respectfully referred to Maj. W. McFarland, Corps of Engineers, for report in connection with previous papers herewith.

JOHN G. PARKE,
Acting Chief of Engineers.

[Third indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
Washington, D. C., December 8, 1879.

Respectfully returned to the Chief of Engineers.

It appears by the report of my assistant engineer at Buffalo that the length of pier that has been actually removed by the Delaware, Lackawanna and Western Railroad

Company is 613 feet, and as the company desires to rebuild only 107 feet more, or a total of 720 feet, I do not see that any public interest of the United States would be prejudiced by allowing them to do so, provided the legal status as to title be secured by proper stipulations as proposed, and the government be not deprived of the boating facilities which it now enjoys at this harbor.

WALTER MCFARLAND,
Major of Engineers.

[Fourth indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
December 8, 1879.

Respectfully returned to the honorable the Secretary of War, inviting attention to the foregoing indorsement of Major McFarland. There seems to be no objection to permitting the railway company to reconstruct the pier for the length of 720 feet upon the conditions named in the letter of Mr. Rogers and in the indorsement of Major McFarland, the stipulation which is to be agreed upon between the United States and the railway company to be submitted to the United States district attorney for his approval, as required by instructions of the Secretary of War December 3, 1879.

Previous papers herewith.

JOHN G. PARKE,
Acting Chief of Engineers.

[Fifth indorsement.]

WAR DEPARTMENT, *December 8, 1879.*

Respectfully returned to the Acting Chief of Engineers, whose views are concurred in and approved, and will be carried out by the proper orders.

GEORGE W. MCCRARY,
Secretary of War.

[Sixth indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
December 8, 1879.

Respectfully referred to Major McFarland, Corps of Engineers, who will please carry out the instructions of the honorable the Secretary of War as set forth in the foregoing indorsements.

JOHN G. PARKE,
Acting Chief of Engineers.

[Seventh indorsement.]

WASHINGTON, D. C., *December 12, 1879.*

Respectfully returned to the Chief of Engineers.

In accordance with the instructions of the previous indorsements, the written stipulation offered by the counsel of the Delaware, Lackawanna and Western Railroad Company was presented by me to the United States district attorney for the northern district of New York for his opinion, which he indorsed upon it as follows:

"With the amendment in my handwriting within made, I think the within contract if signed by the Delaware, Lackawanna, and Western Company will accomplish what the Secretary of War proposes.

"December 9, 1879.

"MARTIN I. TOWNSEND,
"*United States Attorney, Northern District, New York.*"

(See inclosure 1 herewith.)

A copy of this paper, including the amendments made by Mr. Townsend, was then made and signed by Sam. Sloan, president of the Delaware, Lackawanna and Western Company, and sealed with the corporate seal of the company, and is herewith (see inclosure 2).

I then notified the Acting Chief of Engineers of the result, recommending that the military guard be removed from the pier, and, under the authority given me in the original telegraphic instructions to the commanding officer at Fort Porter, I telegraphed him that the company was permitted to resume work, and that I had recommended that orders be issued to withdraw his guard.

WALTER MCFARLAND,
Major of Engineers.

INCLOSURE 1.

This is the same as inclosure 2 which follows, with the exception of the words inserted by the Hon. Martin I. Townsend, which are inclosed in brackets.

INCLOSURE 2.

In the matter of the North Pier of Buffalo Harbor.

In consideration of the action of the authorities of the United States Government, by which the Delaware, Lackawanna and Western Railroad Company is permitted to proceed with the construction of 720 feet of pier on the site of the old North Pier of Buffalo Harbor, it is stipulated and agreed on behalf of said company [that the United States shall be held to be in possession of the new pier to the same extent as they were of the old pier] and that such permission shall not in any manner prejudice any legal or equitable right of the United States of America; that the rights of said the United States of America in the new pier shall be precisely the same as its rights in the old pier: and that no right whatever of said the United States of America shall be prejudiced by anything done or left undone by it before the completion of such new pier by said company. And said company further agrees to furnish on said pier (or on its premises contiguous at such convenient place as the government authorities may suggest) suitable conveniences for boat landing, and boat-house for the use of the government officers and men who shall be engaged in the construction of Buffalo Breakwater and other improvements of Buffalo Harbor.

Nothing herein shall be construed as a waiver of, or shall in any manner impair any right of, said company in the old pier or the premises covered thereby.

In witness whereof the Delaware, Lackawanna and Western Railroad Company has caused this stipulation to be signed by its president and its corporate seal to be affixed thereto, at its office in the city of New York, this 9th day of December, 1879.

SAM. SLOAN,
President.

Attest:
[SEAL.] FRED. F. CHAMBERS,
Secretary.

With the amendment in my handwriting within made, I think the within contract, if signed by the Delaware, Lackawanna and Western Company, will accomplish what the Secretary of War proposes.

December 9, 1879.

MARTIN I. TOWNSEND,
United States Attorney, Northern District of New York.

The "amendment" referred to above appears in the original as an interlineation, and begins with the words "that the United States shall be held to be," and concluding with the words "as they were of the old pier and."

The guard having been withdrawn, and the resumption of work authorized, the railroad company, in accordance with the terms of its stipulation relating to providing the United States with a suitable boathouse at some convenient point on the north pier, or on the company's premises contiguous to it, have built for us a boat-house 24 by 30 feet, fronting on the Erie basin, next to what is known as Coit's Slip, or as near to it at least as the company's property extends.

The site was selected by the company's engineer, Mr. A. Bryson, jr., and myself, in conjunction, and the building is quite as conveniently situated for our own use, and is not so much in the way of the company's operations, as was the old boat-house. Its position is shown on the map herewith.

So, for the present, this controversy is amicably settled.

Buffalo Harbor, New York, is situated within the collection district of Buffalo Creek. It is lighted by a third order fixed white light at the outer end of the south pier; a fixed red fourth order light at the north end of the breakwater; and a fixed white light of the fourth order, varied with white flashes, on Horseshoe Reef, at the entrance to the Niagara River. Fort Porter is within the city limits, on the Niagara River.

The following statement of the commerce of the port for the fiscal year ending June 30, 1880, is, by the courtesy of the collector of customs, furnished from the records of the custom-house:

Revenue from customs	$609,882 17
Value of imports	3,318,257 00
Value of exports	325,027 00
Number of vessels cleared	5,160 00

Their tonnage .... tons..	2,736,593 00
Number of vessels entered	5,151 00
Their tonnage .... tons..	2,580,790 00
Probable number of arrivals and departures of vessels which do not enter and clear	700 00

Chief articles of commerce: grain and lumber.

Money statement.

July 1, 1880, amount available	$178,892 56	
Amount appropriated by act approved June 14, 1880	90,000 00	
		$268,892 56
July 1, 1880, amount expended during fiscal year	78,811 12	
July 1, 1880, outstanding liabilities	110 96	
		78,922 08
July 1, 1880, amount available		189,970 48
Amount (estimated) required for completion of existing project		1,545,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		300,000 00

Abstract of proposals for the extension of Buffalo Breakwater, received and opened at United States Engineer Office, Oswego, N. Y., at 10 o'clock a. m., November 29, 1879, under advertisement of October 29, 1879.

No.	Name and address of bidder.	Oak, approximate quantity, 25,000 ft., b. m.	White pine, approximate quantity, 400,000 ft., b. m.	Hemlock, approximate quantity, 1,200,000 ft., b. m.
1	Syracuse Iron Works, R. H. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson, Geddes, N. Y.; Charles E. Hubbell, Geddes, N. Y.			
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio; Daniel R. Taylor, Cleveland, Ohio.			
3	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio; George W. Steele, Painesville, Ohio.	At $25 per 1,000 ft., b. m., $625.	At $23.50 per 1,000 ft., b. m., $9,400.	At $17.50 per 1,000 ft., b. m., $21,000.
4	Andrew Spaulding, Buffalo, N. Y. Guarantors: Lewis J. Bennett, Buffalo, N. Y.; George Talbot, Buffalo, N. Y.	At $40 per 1,000 ft., b. m., $1,000.	At $22 per 1,000 ft., b. m., $8,800.	At $20 per 1,000 ft., b. m., $24,000.
5	D. E. Bailey, Buffalo, N. Y. Guarantors: George Talbot, Buffalo, N. Y.; William Richardson, Buffalo, N. Y.	At $35 per 1,000 ft. b. m., $875.	At $23 per 1,000 ft., b. m., $9,200.	At $17 per 1,000 ft., b. m., $20,400.
6	John G. Moore, New York, N. Y. Guarantors: John O. Evans, Washington, D. C.; Daniel M. Owen, New York, N. Y.	At $35 per 1,000 ft., b. m., $875.	At $22 per 1,000 ft., b. m., $8,800.	At $16 per 1,000 ft., b. m., $19,200.
7	Gibson & Gager, Buffalo, N. Y. Guarantors: John Reining, Buffalo, N. Y.; August Spitzmiller, Buffalo, N. Y.	At $30 per 1,000 ft., b. m., $750.	At $19 per 1,000 ft., b. m., $7,600.	At $15.50 per 1,000 ft., b. m., $18,600.
8	George Kellogg, Fulton, N. Y. Guarantors: F. D. Van Waggenan, Fulton, N. Y.; O. J. Jennings, Fulton, N. Y.	At $37 per 1,000 ft., b. m., $925.	At $28 per 1,000 ft., b. m., $11,200.	At $23 per 1,000 ft., b. m., $27,600.

Abstract of proposals for the extension of Buffalo Breakwater, &c.—Continued.

No.	Name and address of bidder.	Gravel, approximate quantity, 20,000 cu. yds.	Stone, broken and filling, approximate quantity, 25,000 cu. yds.	Stone, riprip, approximate quantity, 1,800 tons.
1	Syracuse Iron Works, R. H. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson, Geddes, N. Y.; Charles E. Hubbell, Geddes, N. Y.			
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio; Daniel R. Taylor, Cleveland, Ohio.			
3	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio; George W. Steele, Painesville, Ohio.	At 60 cents per cu. yd., $12,000.	At $1.12 per cu. yd., $28,000.	At $1.50 per ton, 2,240 lbs., $2,700.
4	Andrew Spaulding, Buffalo, N. Y. Guarantors: Lewis J. Bennett, Buffalo, N. Y.; George Talbot, Buffalo, N. Y.	At 60 cents per cu. yd., $12,000.	At $1.20 per cu. yd., $30,000.	At $1.25 per ton, 2,240 lbs., $2,250.
5	D. E. Bailey, Buffalo, N. Y. Guarantors: George Talbot, Buffalo, N. Y.; William Richardson, Buffalo, N. Y.	At 50 cents per cu. yd., $10,000.	At $1.05 per cu. yd., $26,250.	At $1.25 per ton, 2,240 lbs., $2,250.
6	John G. Moore, New York, N. Y. Guarantors: John O. Evans, Washington, D. C.; Daniel M. Owen, New York, N. Y.	At $1 per cu. yd., $20,000.	At $1 per cu. yd., $25,000.	At $1 per ton, 2,240 lbs., $1,800.
7	Gibson & Gager, Buffalo, N. Y. Guarantors: John Reining, Buffalo, N. Y.; August Spitzmiller, Buffalo, N. Y.	At 80 cents per cu. yd., $16,000.	At 91 cents per cu. yd., $22,750.	At 75 cents per ton, 2,240 lbs, $1,350.
8	George Kellogg, Fulton, N. Y. Guarantors: F. D. Van Waggenan, Fulton, N. Y.; O. J. Jennings, Fulton, N. Y.	At 70 cents per cu. yd., $14,000.	At $1.25 per cu. yd., $31,250.	At $2.50 per ton, 2,240 lbs., $4,500.

No.	Name and address of bidder.	Dredging, approximate quantity, 25,000 cu. yds.	Bolts, screw and washers, approximate quantity, 4,000 lbs.	Bolts, drift, approximate quantity, 300,000 lbs.
1	Syracuse Iron Works, R. H. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson, Geddes, N. Y.; Charles E. Hubbell, Geddes, N. Y.	....	At $6\frac{1}{4}$ cents per lb., $250.	At $3\frac{4}{10}$ cents per lb., $10,200.
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio; Daniel R. Taylor, Cleveland, Ohio.	....	At $4\frac{94}{100}$ cents per lb. $197.60.	At $3\frac{79}{100}$ cents per lb., $11,370.
3	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio; George W. Steele, Painesville, Ohio.	At 50 cents per cu. yd., $12,500.		
4	Andrew Spaulding, Buffalo, N. Y. Guarantors: Lewis J. Bennett, Buffalo, N. Y.; George Talbot, Buffalo, N. Y.	At 50 cents per cu. yd., $12,500.		
5	D. E. Bailey, Buffalo, N. Y. Guarantors: George Talbot, Buffalo, N. Y.; William Richardson, Buffalo, N. Y.	At 50 cents per cu. yd., $12,500.		
6	John G. Moore, New York, N. Y. Guarantors: John O. Evans, Washington, D. C.; Daniel M. Owen, New York, N. Y.	At 40 cents per cu. yd., $10,000.		
7	Gibson & Gager, Buffalo, N. Y. Guarantors: John Reining, Buffalo, N. Y.; August Spitzmiller, Buffalo, N. Y.	At 55 cents per cu. yd., $13,750.		
8	George Kellogg, Fulton, N. Y. Guarantors: F. D. Van Waggenan, Fulton, N. Y.; O. J. Jennings, Fulton, N. Y.	At 70 cents per cu. yd., $17,500.		

Abstract of proposals for the extension of Buffalo Breakwater, &c.—**Continued.**

No.	Name and address of bidder.	Spike, approximate quantity, 9,000 lbs.	Totals.
1	Syracuse Iron Works, R. H. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson, Geddes, N. Y.; Charles E. Hubbell, Geddes, N. Y.	At 4¾ cents per lb., $427.50.	$10 677 50
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio; Daniel R. Taylor, Cleveland, Ohio.	At 4 94/100 cents per per lb., $444.60.	12 012 20
3	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio; George W. Steele, Painesville, Ohio.	....	86,225 00
4	Andrew Spaulding, Buffalo, N. Y. Guarantors: Lewis J. Bennett, Buffalo, N. Y.; George Talbot, Buffalo, N. Y.	....	90,550 00
5	D. E. Bailey, Buffalo, N. Y. Guarantors: George Talbot, Buffalo, N. Y.; William Richardson, Buffalo, N. Y.	....	81,475 00
6	John G. Moore, New York, N. Y. Guarantors: John O. Evans, Washington, D. C.; Daniel M. Owen, New York, N. Y.	....	85,675 00
7	Gibson & Gager, Buffalo, N. Y. Guarantors: John Reining, Buffalo, N. Y.; August Spitzmiller, Buffalo, N. Y.	....	80,900 00
8	George Kellogg, Fulton, N. Y. Guarantors: F. D. Van Waggenan, Fulton, N. Y.; O. J. Jennings, Fulton, N. Y.	....	106,975 00

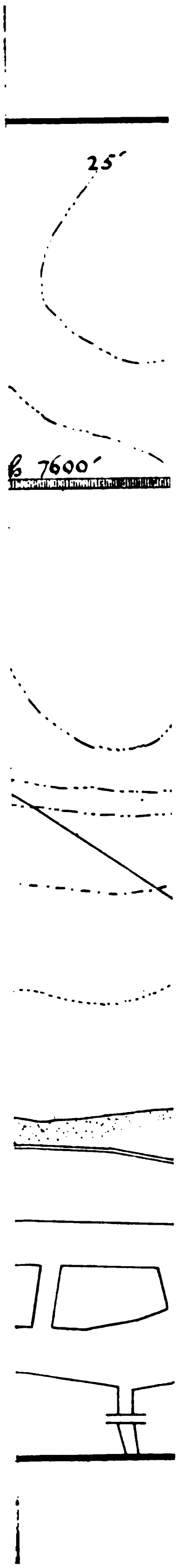
Abstract of proposals for the extension of Buffalo breakwater, received and opened at United States Engineer Office, Oswego, N. Y., at 12 o'clock m., February 4, 1880, under circular of January 30, 1880.

Name and address of bidder.	Bolts, screw and washer, approximate quantity, 4,320 pounds.	Bolts, drift, approximate quantity, 320,194 pounds.	Spike, approximate quantity, 9,500 pounds.	Totals.
Pascal P. Pratt and Edward P. Beale, Pratt & Co., Buffalo, N. Y. Guarantors: John M. Horton, Buffalo, N. Y.; David E. Brown, Buffalo, N. Y.	At 6½ cents per pound, $280.80.	At 4.2 cents per pound, $13,448.15.	At 6 cents per pound, $570.	$14,298 95
Frank Wilson, Cleveland, Ohio. Guarantors: Peter M. Hitchcock, Cleveland, Ohio; Martyn Bonnell, Cleveland, Ohio.	At 6¼ cents per pound, $270.70.	At 4.55 cents per pound, $14,568.83.	At 5 cents per pound, $475.	15,313 83

Abstract of contracts for improving harbor at Buffalo, N. Y., entered into during the fiscal year ending June 30, 1880.

Name of contractor.	Sureties.	Material.	Price.
Pascal P. Pratt and Edward P. Beale, under the firm name of Pratt & Company, Buffalo, N. Y.*	David E. Brown, of Buffalo, N. Y.; John M. Horton, of Buffalo, N. Y.	Screw and washer bolts.	6½ cents per pound.
		Drift bolts	4.2 cents per pound.
		Spike	6 cents per pound.
Daniel E. Bailey, of Buffalo, N. Y.†	George Talbot, of Buffalo, N. Y.; William Richardson, of Buffalo, Y. N.	White pine	$23 per 1,000 feet, b. m.
		Hemlock	$17 per 1,000 feet, b. m.
		Oak	$35 per 1,000 feet, b. m.
		Dredging	50 cents per cubic yard.
		Gravel filling	50 cents per cubic yard.
		Stone filling	$1.05 per cubic yard.
		Riprap stone	$1.25 per ton of 13 cubic feet.

* Contract entered into February 20, 1880; expires March 31, 1880.
† Contract entered into January 27, 1880; expires November 30, 1880.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J J 3.

IMPROVEMENT OF WILSON HARBOR, NEW YORK.

Nothing has been done here during the year, the few hundred dollars available not being sufficient to justify undertaking any work, and the harbor is in the same condition as given in my last annual report.

The appropriation of $10,000 made June 14, 1880, will be applied to the extension of both piers.

The scheme for the improvement of this harbor, adopted by appropriation in 1875, provided for the construction of piers out to the 12-foot curve, and excavating a channel between them 12 feet deep. The piers have been carried to the 8-foot curve, and the channel deepened to 8 feet, at a cost of about $19,000. The appropriation of $30,000 asked for is for the continuation of this work.

The present condition of this harbor is shown by the map which accompanied my last year's report upon it.

Wilson Harbor, New York, is in the collection district of Niagara, at the mouth of Twelve-Mile Creek, 12 miles east of the mouth of the Niagara River and Fort Niagara, and 6 miles west of Olcott Harbor, New York, where is situated the nearest lighthouse.

The following statement of the commerce of the port of Wilson for the fiscal year ending June 30, 1880, is furnished by the courtesy of the collector of customs from the records of the custom-house at Suspension Bridge, N. Y.:

Revenue from customs	$1,523 48
Value of imports	$8,937 00
Value of exports	$57 00
Number of vessels cleared	22
Their tonnage ... tons	1,598
Number of vessels entered	21
Their tonnage ... tons	1,557
Probable number of arrivals and departures not entering or clearing	25

Chief articles of commerce: lumber, grain, and fruit.

Money statement.

July 1, 1879, amount available	$898 41	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$10,898 41
July 1, 1880, amount available		10,898 41
Amount (estimated) required for completion of existing project		70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		30,000 00

J J 4.

IMPROVEMENT OF OLCOTT HARBOR, NEW YORK.

Nothing has been done during the year, there being no funds available, and the condition of the harbor is the same as given in my last annual report.

The scheme for the improvement of this harbor was adopted by appropriation in 1867, and provided for the construction of parallel piers extending out to the 12-foot curve and the excavation of a channel 12 feet deep between them. The piers have been carried out to the 9-foot curve, and the channel deepened to about 10 feet, at a cost of $115,000. The appropriation of $10,000 asked for is for the completion of this work.

The present condition of this harbor is shown by the map which accompanied my last year's report upon it.

Olcott Harbor, New York, is in the collection district of Niagara, at the mouth of Eighteen-Mile Creek, 18 miles east of the mouth of the Niagara River and Fort Niagara. It is lighted by a fixed white light of the sixth order, placed near the head of the west pier.

The following statement of the commerce of the port for the fiscal year ending June 30, 1880, is furnished through the courtesy of the collector of customs from the records of the custom-house at Suspension Bridge, N. Y.:

Revenue from customs	$29[illegible] 05
Value of imports	$432 00
Value of exports	$7,[illegible]15 00
Number of vessels cleared	[illegible]
Their tonnage ...tons..	5,4[illegible]
Number of vessels entered	62
Their tonnage ...tons..	4,7[illegible]
Probable number of arrivals and departures not entering or clearing	19

Chief articles of commerce: lumber, fruit, and grain

Money statement.

Amount (estimated) required for completion of existing project	$10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	10,000 00

J J 5.

IMPROVEMENT OF OAK ORCHARD HARBOR, NEW YORK.

Nothing has been done here during the year, and the harbor is in the same good condition as reported last year. The funds now available will be applied to the rebuilding of both piers.

The present condition of this harbor is shown by the map which accompanied my last year's report upon it.

Oak Orchard Harbor, New York, lies in the collection district of Genesee, nearly midway between the mouths of the Genesee and the Niagara Rivers, being about 30 miles from the former and 45 miles from the latter, forming the only good harbor of refuge between these points for vessels drawing as much as 11 feet of water. It is lighted by a fixed white light of the fourth order, placed at the end of the west pier.

The following statement of the commerce of the port for the fiscal year ending June 30, 1880, is furnished by the courtesy of the collector of customs at Rochester from the records at the custom-house:

Revenue from customs	$2,811
Value of imports	$15,818
Number of vessels cleared	10
Their tonnage ...tons..	800
Number of vessels entered	14
Their tonnage ...tons..	1,152
Probable number of arrivals and departures not entering or clearing	59

Chief articles of commerce: lumber, grain, and fruit

Money statement.

July 1, 1879, amount available	$3,290 31	
Amount appropriated by act approved June 14, 1880	500 00	
		$3,790 31
July 1, 1880, amount expended during fiscal year		14 44
July 1, 1880, amount available		3,775 87
Amount (estimated) required for completion of existing project		500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		500 00

J J 6.

IMPROVEMENT OF CHARLOTTE HARBOR, NEW YORK.

The appropriation of $1,000, March 3, 1879, was made for "repair of piers."

REPAIRS MADE—EAST PIER.

The end of the east pier was repaired by renewing the deck joists and plank, and filling with stone where needed. A break 200 feet from the north end of the pier was also repaired; the west wall, where the break occurred, rebuilt for a depth of eight courses below the water line and length of 22 feet, and the empty space filled with stone.

At various points on this pier south of the break, up to the ferry slip, rotten cross-ties, wall timbers and deck plank were taken up and replaced by new.

WEST PIER.

Two small breaks were closed, wall timbers and cross-ties put in, old deck plank replaced by new, and loose ones respiked.

MATERIAL EXPENDED.

32,881 feet, board measure, timber and plank	$460 33
3,607 pounds new iron	131 88
300 pounds old iron straightened and used.	
33$\frac{3}{5}$ cords stone	134 40
Tools and freight	35 73
Labor	443 06
Total	1,205 40

The appropriation of $5,000 made by act of June 14, 1880, will be applied to the rebuilding of the piers, the estimated cost of which was $45,000, as given in the last annual report.

Charlotte Harbor, New York, is in the collection district of Genesee, and is the port of the city of Rochester, 7 miles distant. It is formed by the mouth of the Genesee River, and lies about midway between Oswego and the mouth of the Niagara River. It is lighted by a fixed white light of the fourth order on the bluff, and by a fixed white light of the sixth order at the lake end of the west pier.

The following statement of the commerce of the port for the fiscal year ending June 30, 1880, is furnished from the records of the custom-house at Rochester, through the courtesy of the collector:

Revenue from customs	$35,922 44
Value of imports	$229,003 00
Value of exports	$127,409 00
Number of vessels cleared	603
Their tonnage ... tons..	139,112
Number of vessels entered	590
Their tonnage ... tons..	134,076
Probable number of arrivals and departures not entering or clearing....	180

Chief articles of commerce: lumber, live stock, grain, iron ore, coal, and hay.

Money statement.

July 1, 1879, amount available	$1,958 08	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$6,958 08
July 1, 1880, amount expended during fiscal year		1,384 05
July 1, 1880, amount available		5,574 03
Amount (estimated) required for completion of rebuilding piers, existing project		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		10,000 00

J J 7.

IMPROVEMENT OF PULTNEYVILLE HARBOR, NEW YORK.

The operations for the year have been confined to the extension of the piers.

The west pier was lengthened lakeward 93½ feet by sinking three cribs, each 20 by 30 feet, and covering them with superstructure, thus giving the west pier a total length 664.6 feet.

The east pier was connected with Reynolds's Wharf by sinking three cribs, measuring 16 by 30 feet, 16 by 30 feet, and 16 by 25.6 feet, respectively, on the line of the pier shoreward, thus closing a gap of 86 feet, and giving the east pier a total length of 563 feet.

The cost of extending both piers was—

For material	$2,351 34
For labor	907 95
Total	3,259 29

In filling the gap on the east pier, the bottom had to be leveled, as there were stones and timbers belonging to the old work in the line on which the cribs were afterwards sunk.

October 4, 1879, an agreement was made with C. F. Dunbar for dredging the channel at 18 cents per cubic yard, measured in scows, and under this agreement dredging was begun April 21, 1880. At that date there was but 3 feet depth at the entrance to the inner harbor, or 1¼ feet at extreme low-water level, a vessel drawing 3¼ feet being unable to leave the harbor.

By June 30 the channel had been deepened to 8 feet at extreme low-water level, or 10 feet at the present stage, over 20,000 cubic yards of sand and other material having been removed, including one bowlder of 100 feet cubic contents.

The appropriation of $3,000 made by act of June 14, 1880, will be applied to the further extension of the piers.

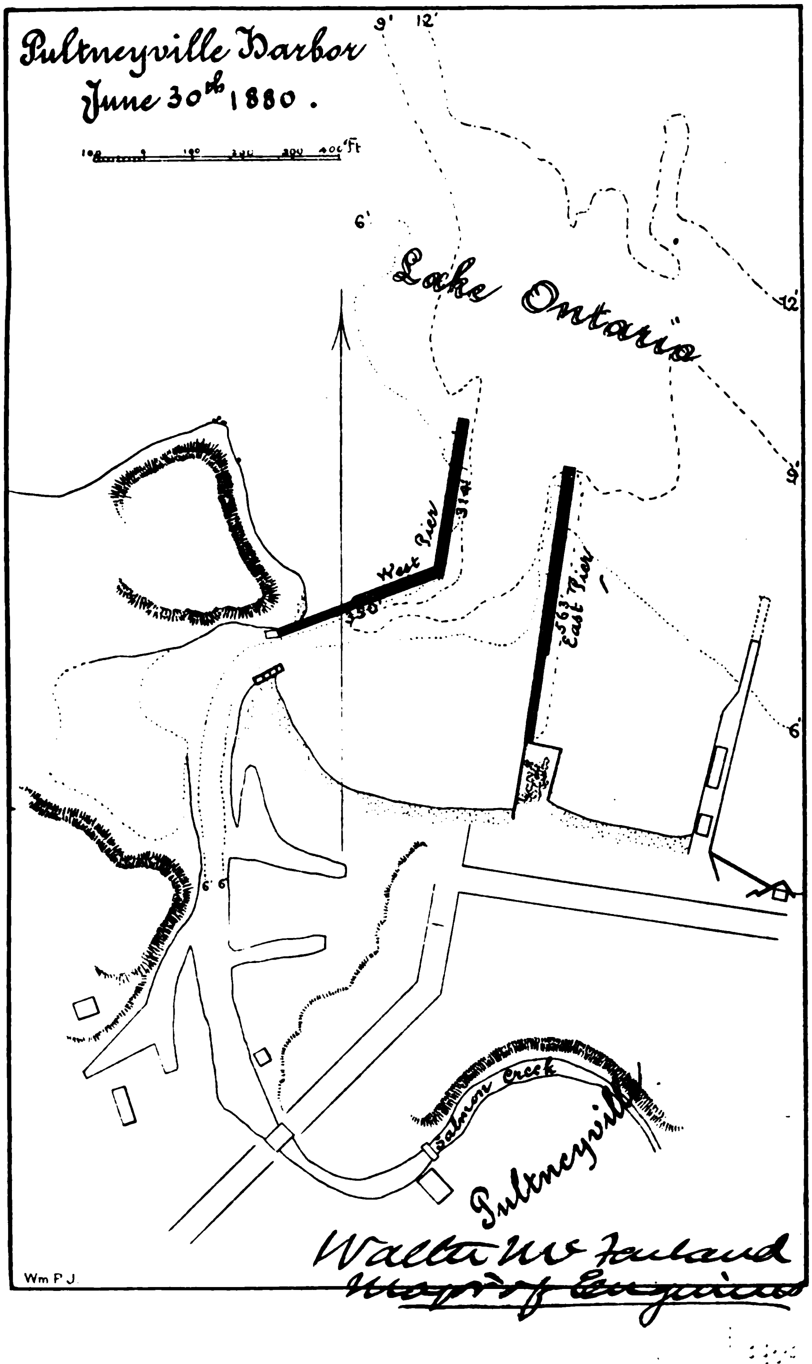
The scheme for the improvement of this harbor was adopted by appropriation in 1870, and provides for the construction of an east and west pier and the excavation of a channel between them. The piers have been carried out to the 8-foot curve and the channel deepened to 8 feet, at a cost of about $60,000. The appropriation of $6,000 called for is for the further extension of the piers and the deepening of the channel.

Pultneyville Harbor, New York, is in the collection district of Genesee, about 40 miles west of Oswego and a little more than 20 miles east of the mouth of the Genesee River. It is not lighted. The nearest light-house is at Great Sodus Bay, about 12 miles to the eastward.

Through the courtesy of the collector of customs at Rochester, the following statistics of the commerce of this port are furnished from the records of the custom-house for the fiscal year ending June 30, 1880:

Revenue from customs	$770 89
Value of imports	$5,867 00
Number of vessels cleared	32
Their tonnage ... tons..	1,389
Number of vessels entered	32
Their tonnage ... tons..	1,471
Probable number of arrivals and departures not entering or clearing	20

Chief articles of commerce: lumber, shingles, lath, fruit, grain, and fresh fish.


Pultneyville Harbor
June 30th 1880.
100 0 100 200 300 400 Ft
Lake Ontario
West Pier
314
330
East Pier
563
Salmon Creek
Pultneyville
Wm P J.
Walter McFarland
Major of Engineers

Money statement.

July 1, 1879, amount available	$9,576 43	
Amount appropriated by act approved June 14, 1880	3,000 00	
		$12,576 43
July 1, 1880, amount expended during fiscal year	7,248 50	
July 1, 1880, outstanding liabilities	368 14	
		7,616 64
July 1, 1880, amount available		4,959 79
Amount (estimated) required for completion of existing project		6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		6,000 00

J J 8.

IMPROVEMENT OF HARBOR AT GREAT SODUS BAY, NEW YORK.

During the year, 825 linear feet of the superstructure of the west pier was rebuilt four courses in height.

The balance of the old appropriation, and the new appropriation of $3,000 made by act of June 14, 1880, will be applied to the rebuilding of the piers and to dredging the channel.

The original scheme for the improvement of this harbor was adopted by appropriation in 1829, and provided for two breakwaters extending from the east and west shores, respectively, running towards the channel, and terminating at the channel end by two parallel piers running lakeward, and was completed some years ago.

The appropriation of $10,000 asked for is for the purpose of deepening the channel between the piers to 12 feet, and extending the east pier to the 12-foot curve.

COST OF REPAIRS MADE DURING THE YEAR.

221,075 feet, board measure, pine timber and plank	$3,095 05
13 oak snubbing posts	58 50
20,105 pounds bolts and spike	662 34
Scow hire, tools, freight, &c	186 36
Labor, including superintendence	2,457 97
Total	6,460 22

Great Sodus Harbor, New York, is in the collection district of Oswego, from which it is distant about 32 miles. It is lighted by a coast-light of the fourth order, on the bluff, fixed white, varied by white flashes and by two sixth-order white beacon-lights, one at each end of the west pier.

Through the courtesy of the collector of customs at Oswego, I have been furnished from the records of the custom-house with the following statistics of the commerce of the port of Great Sodus (Sodus Point) for the fiscal year ending June 30, 1880:

Revenue from customs	$1,609 32
Value of imports	$10,919 57
Value of exports	$91,047 48
Number of vessels cleared	125
Their tonnage .... tons..	16,250
Number of vessels entered	127
Their tonnage .... tons..	16,490
Probable number of other vessels arriving and departing	30

Chief articles of commerce: coal, lumber, and iron ore.

Money statement.

July 1, 1879, amount available	$9,274 71	
Amount appropriated by act approved June 14, 1880	3,000 00	
		$12,274 71
July 1, 1880, amount expended during fiscal year		5,437 80
July 1, 1880, amount available		6,836 91
Amount (estimated) required for completion of existing project		17,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		10,000 00

J J 9.

IMPROVEMENT OF LITTLE SODUS HARBOR, NEW YORK.

During the year the work on the piers at this harbor has been confined to repairs.

REPAIR OF EAST PIER.

One hundred and fifty-five linear feet of decking were taken up, the stone filling levelled up to its proper height, and the deck plank replaced. The superstructure was leveled up for 26 feet of this distance

REPAIR OF WEST PIER.

There were torn down and rebuilt portions of the west pier as follows:

55 linear feet of fifth course.
170 linear feet of fourth course.
486 linear feet of third course.
510 linear feet of second course.
1,010 linear feet of first course or top.

The whole length of the pier, 1,023 feet, was redecked.

MATERIAL USED.

Oak snubbing posts, 684 feet, board measure	$23 94
Pine timber and plank, 157,140 feet, board measure	2,199 96
Bolts, 16,067 pounds	562 34
Spike, 2,870 pounds	93 27
Stone, 84.84 cords	254 52
Labor, including superintendence	2,494 50
Total cost of repairs	5,628 53

On the 15th of October a contract was formed with C. F. Dunbar, of Port Colborne, Ontario, under circular letter dated September 25, calling for proposals, and specifications dated September 22, 1879, for dredging the channel inside, between, and outside the piers at Little Sodus Harbor, New York, extending over an area of 1,900 by 210 feet, 12 feet at zero of the gauge, or extreme low-water level, being the depth of water to be obtained.

Approximate quantity of material to be removed, 28,000 cubic yards, the rate to be paid being 18 cents per cubic yard, measured in the scows.

Under this contract, work commenced at the south end of the channel on the west side on October 16, 1879, and continued until November 24, when the dredge was laid up for the winter. Nine thousand four hundred and eighty cubic yards of material were removed in a straight cut 100 feet wide along the channel face of the west pier, from the 12-foot

curve inside the bay to the 12-foot curve outside the piers, the shoalest spot in the cut being 11 feet below zero of the gauge, or at ordinary lake-level 13 feet.

The dredging under this contract recommenced April 17, 1880. After working a part of two days, during which $198\frac{7}{10}$ cubic yards of material were dredged, the dredge was removed temporarily to Pultneyville, to release a vessel shut up there by the closing of the channel with sand from the beach.

This rendered it necessary to extend Dunbar's contract for doing the work at Little Sodus Harbor, and upon my recommendation this was accordingly done, January, 1881, being fixed as the date for the completion of the work.

The original scheme for the improvement of this harbor was adopted by appropriation in 1852, and was identical with the scheme for the improvement of Big Sodus Harbor.

It was completed some years ago. The appropriation of $20,000 now called for is for the purpose of extending the east pier and deepening the channel to 12 feet, as recommended in my last annual report.

Little Sodus Harbor, New York (Fairhaven), is in the collection district of Oswego, about 12 miles west of Oswego and Fort Ontario. It is lighted by a fixed white light of the fourth order, situated near the head of the west pier.

The following statement of the commerce of the port for the fiscal year ending June 30, 1880, is furnished from the records of the custom-house, through the courtesy of the collector of customs at Oswego:

Revenue from customs	$45,583 50
Value of imports	$250,000 00
Value of exports	$120,000 00
Number of vessels cleared	221
Their tonnage	23,946
Number of vessels entered	220
Their tonnage	23,941
Probable number of other vessels arriving and departing	30

Chief articles of commerce: lumber, grain, iron ore, and coal.

Money statement.

July 1, 1879, amount available	$15,489 33	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$35,489 33
July 1, 1880, amount expended during fiscal year	8,359 04	
July 1, 1880, outstanding liabilities	206 40	
		8,565 44
July 1, 1880, amount available		26,923 89
Amount (estimated) required for completion of existing project		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

Abstract of proposals for dredging at the harbor of Little Sodus Bay, New York, received and opened at United States Engineer Office, Oswego, N. Y., at 11 o'clock a. m., October 2, 1879, under circular of September 22, 1879.

Name and address of bidder.	Dredging, approximate quantity 28,000 yards, scow measurement.	Total.
Charles F. Dunbar, Port Colborne, Canada. Guarantors: Franklin Lee, Buffalo, N. Y.; J. H. Lee, Buffalo, N. Y.	At 18 cents per cubic yard, $5,040.	$5,040 00

Abstract of contract for improving harbor at Little Sodus Bay, New York, entered into during the fiscal year ending June 30, 1880.

Name of contractor.	Sureties.	Material.	Price.
Charles F. Dunbar, Port Colborne, Ontario, Canada.	Franklin Lee, of Buffalo, N. Y.; J. H. Lee, of Buffalo, N. Y.	Dredging	18 cents per cubic yard, scow measurement.

Contract entered into October 15, 1879; expires June 30, 1880.

J J 10.

IMPROVEMENT OF OSWEGO HARBOR, NEW YORK.

The operations at this harbor during the past fiscal year have consisted of the extension and repair of the new breakwater and the repair of the old breakwater, by the system of hired labor.

NEW BREAKWATER.

Between July 1 and the close of navigation, 1879, twenty-three cribs for the extension of the new breakwater had been built, and twenty-one of them had been sunk in its prolongation. Two of these cribs were 30 feet by 35 feet, all the others being 35 feet square. Each of these smaller cribs had been united with one of the square cribs, thus forming two cribs, each 35 feet wide and 65 feet long, which it was intended to place at right angles to the general line of the breakwater, to serve as part of the breakwater and buttress combined; but this was not done; and the only one of them which was sunk this year was sunk with its long axis in the line of the breakwater. Subsequently, two of the square cribs were united in the same manner, making one crib 35 feet wide and 70 feet long. This was the last crib sunk, its long axis being in the line of the breakwater. But before it could be filled with stone, it was caught by the gale of October 30, lasting three days, which tore off the upper unfilled half of it, and brought it ashore against the old breakwater, in the angle near the light-house.

Several efforts to pull it off when the weather permitted having failed, it was taken to pieces, about half the timbers and all the iron being saved. The weather becoming uncertain, and making it difficult to get the necessary stone filling from the quarries on the Lake shore, from which the most of it had to be brought, it was decided to make no attempt that season to repair the damage to the 70-foot crib, but to riprap it and leave it to be completed in the spring.

For the same reason it was decided not to attempt to sink the last built double crib, 30 feet by 65 feet, but to put it into winter quarters and sink it in the spring. The superstructure was built over all the sunken cribs except the damaged one, being raised only 4 feet high for the last 350 feet. The damaged crib was repaired in the spring of 1880, and was in readiness for its superstructure by the end of the fiscal year.

The total length added to the new breakwater during the fiscal year ending June 30, 1880, is 747 feet, making its total length at that date 5,113 feet; of which all but 70 feet is covered with its superstructure.

This length is made up as follows:

Shore arm .... feet..		910
Lake arm, July 1, 1879 .... do..		3,456
Added during the past year—		
Twenty cribs, 35 feet each .... feet..	700	
One crib, 30 feet .... do..	30	
Sum of intervals between cribs gained in sinking and settling .... do..	17	
		747
July 1, 1880. Total length .... feet..		5,113

It is expected to add to this before the close of the present working season of 1880, under the appropriation of March 3, 1879, an additional length of 450 feet. This is less by 150 feet than was contemplated in my last annual report; and this is due partly to the fact that wages, both for carpenters and for laborers, are 25 cents a day higher than they were last year, and partly to the fact that the settlement of the breakwater heretofore has been so great, compelling large expenditures for repairs, that I have thought it advisable this season to form a foundation for it by excavating a trench in the sandy bottom 4 feet deep and filling it with broken stone.

This, of course, is extra work, involving extra cost not provided for in the original estimate for the construction of the breakwater; but it will undoubtedly save a larger amount that would otherwise have to be expended in repairs, and will leave the work in much better shape.

The last appropriation of $90,000, made by act of Congress approved June 14, 1880, will enable us to finish the new breakwater on the west side of the river, and to do some dredging in the inner harbor, which is very necessary in view of the probable opening of the enlarged Welland Canal next summer.

The estimated cost of this new breakwater, 5,800 feet in length, as originally given was $232.89 per linear foot of structure, reduced 14 per cent. on a subsequent revision, which put the probable cost per linear foot at $200.29, making the total estimated cost of 5,800 feet $1,161,682, which, in the estimate of the amount required for the completion of this work, I have called			$1,162,000
Under this estimate the following appropriations have been made, viz:			
July 11, 1870		$50,000	
March 3, 1871		100,000	
June 10, 1872		100,000	
March 3, 1873		100,000	
June 23, 1874		75,000	
March 3, 1875		90,000	
August 14, 1876		90,000	
1877. No appropriation.			
June 18, 1878		90,000	
March 3, 1879		90,000	
June 14, 1880		90,000	
Total		875,000	
Of this there have been expended in rebuilding the old breakwater and repairing the new about	$92,000		
And of the present appropriation there will probably be applied to dredging the inner harbor	20,000		
		112,000	
Total original cost of new breakwater, including work to be done under the present appropriation			763,000
Balance of original estimate			399,000

It will be observed that the amounts already appropriated for this breakwater, which are enough to complete it, fall nearly $400,000 below the amount of the orignal estimate for its construction. This is due to the fact that nearly all the materials which enter into its composition

have fallen at least one-half in price since that estimate was made, while the cost of labor itself has been reduced very greatly.

When this breakwater is completed in accordance with the original design, there will be an opening of from 600 to 700 feet in width between its eastern end and the northern end of the light-house pier, concerning which the report of the Board of Engineers of March 30 and 31, 1870, says:

> The width of this opening may be reduced, should it be found that the waves roll in so as to incommode shipping at the wharves.

My own opinion is that the best way to protect this opening is to reduce it to 350 feet by building from the eastern end of the breakwater as originally proposed an arm running southwardly towards the beacon, and then continuing the main arm of the breakwater eastwardly in front of the eastern half of the city, leaving between the eastern end of the western breakwater now built and the western end of the eastern breakwater now proposed an opening of 350 feet, for the passage of the river; which is the width of the opening between the light-house and the old east pier, through which it now passes.

The effect of this would be to secure a good entrance, in all weathers, to all parts of the harbor—western, eastern, and inner—to get rid of the dangerous sea which is now created in the very entrance of the harbor by the conflict of the river water and the waves produced by gales from the northward and eastward, as there would be no reaction from the light-house pier, and the river water would lose a good deal of its velocity by dispersion before reaching the new entrance and meeting the waves; and, finally it would give to that half of the city of Oswego which lies on the east side of the river the same harbor advantages that will now be enjoyed by the west side, by securing to it additional anchorage and wharfage room, as recommended in a resolution of the Oswego Board of Trade passed January 4, 1872, to be found at page 268 of the Report of the Chief of Engineers for that year.

All this can be accomplished by the expenditure of the balance of the original estimate remaining after the new west breakwater shall have been completed next year as originally designed, for the present work has not cost over $130 per linear foot, including repairs, and at this rate the balance remaining, if nothing unusual happens, would permit the construction of an eastern breakwater 2,700 feet long, which is a little less than half the proposed length of the west breakwater.

I have, therefore, to recommend that this be authorized, and make the usual requisition for next year's work.

In the construction of the 747 linear feet of new breakwater added during the fiscal year ending June 30, 1880, the following amounts of material and labor were used; the completed work costing about $103 per linear foot for actual construction, or, including contingent expenses, about $120 per linear foot:

White-pine timber and plank, 587,798 feet, board measure, average rate, $14.39		$8,455 07
Hemlock timber and plank, 1,353,928 feet, board measure, average rate, $12.85		17,404 21
Oak timber, 4,288 feet, board measure, at $28		120 06
Total timber		25,979 34
Iron, drift bolts, 159,492 pounds at average rate, 2¾ cents	$4,383 39	
Screw bolts, 11,134 pounds at average rate, 3.52 cents	391 92	
Screw bolts, 1,980 paunds, fabricated, old iron.		
Spike, 10,481 pounds at average rate, 3¾ cents	394 39	
Total iron		5,169 70

Stone, 5,871.82 cords	$25,632 19
Tug hire	1,917 47
Labor and services, including superintendence and office	18,369 36
Total	77,068 06

REPAIR OF NEW BREAKWATER.

During July and August, 1879, none but minor repairs were made on the new breakwater. In September the repair of the superstructure at the west end of the lake arm was begun by replacing, by new materials, the deck joists and timbers which were broken and decayed, filling with stone and relaying the deck plank.

Instead of raising the outside of that part of the new breakwater east of the angle, which is most exposed to damage by gales, 4 feet higher as had been proposed, and as was mentioned in my last annual report, it was decided to try, first, as suggested by the Chief of Engineers, the effect of giving it a close decking, which would prevent the water from passing freely beneath it, as it did beneath the old decking, which was laid with intervals of from 2 to 3 inches between the plank.

This tight decking was put on for a distance of 376 feet along the lake arm, beginning at a point about 100 feet from the angle of the breakwater, and so far it has answered the purpose perfectly well, no damage having been done to it during the winter, though it is to be observed that the winter was a mild one, quite free from gales.

No further repairs were made until June, 1880, when the deck was removed from 133 linear feet of last year's new work which had settled; 35 linear feet of this was leveled, and work on the remainder of it was in progress at the close of the fiscal year.

To the repairs here specified, the following-named materials and labor were applied:

White-pine timber and plank, 85,102 feet, board measure, at $16.50		$1,404 18
Hemlock timber and plank, 59,489 feet, board measure, at $13.50		803 10
Oak timber, 3,099 feet, board measure, at $28		86 77
Total timber		2,294 05
Iron, drift bolts, 12,144 pounds, average rate 2¾ cents	$333 96	
Screw bolts, 1,334 pounds, average rate 3.52 cents	46 96	
Spike, 4,722 pound, average rate 3¾ cents	177 07	
Total iron		557 99
Stone, 365.15 cords, at $4		1,461 60
Tug hire		213 00
Labor and services, including superintendence and office		1,989 74
Total		6,516 38

REPAIR OF OLD BREAKWATER.

Extensive repairs were made to this structure between July and December, 1879.

The rebuilding of the southeast part of the old breakwater, near the light-house, which had been begun in the preceding year was finished. It had been partly undermined by the action of the sea. After its repair further damage of this kind was guarded against by riprapping the angle with fourteen blocks of stone, averaging over a ton each, taken from the wreck of the old stone pier. The north half of this breakwater, from the light-house 400 feet westward, was rebuilt from its foundation up, and a length of 220 feet more was repaired. The en-

tire deck was relaid and much of it was renewed, and the stone filling was replaced where needed.

To these repairs the following specified materials and labor where applied:

White-pine timber and plank, 234,099 feet, board measure		$3,582 64
Hemlock timber, 180 feet feet, board measure, at $13.50		2 43
Oak timber and plank, 4,166 feet, board measure, at $28		116 65
		3,701 72
Iron, drift bolts, 31,882 pounds, at 2¾ cents	$876 75	
Screw bolts, 286, at 3.52 cents	9 07	
Spike, 4,624 pounds, at 3¾ cents	173 40	
		1,059 22
Stone, 647.48 cords, at $4		1,869 92
Tug hire		92 58
Labor and services, including superintendence and office		3,185 53
Total		9,908 97

In addition to the work of construction and repair of the new and old breakwaters which have been detailed a considerable amount of incidental work has been done.

This work includes the repair of the derricks used in building cribs; the hauling out in the fall of the scows, boats, and steam rod-driver Terrapin, and their repair, painting, and launching in the spring.

The total cost of the labor and services which have been thus applied has been $2,406.01.

Oswego Harbor, New York, is in the collection district of Oswego, at the mouth of the Oswego River, through which the waters of the great chain of lakes in Central New York empty themselves into Lake Ontario. The harbor is lighted by a fixed white light of the third order at the eastern or channel end of the old breakwater, and by a red beacon light at the outer end of the light-house pier. Fort Ontario lies at the mouth of the river, on the east side.

Oswego is the only American city on Lake Ontario, the Canadian cities of Kingston and Toronto, on the other shore of the lake, being distant from Oswego about 50 and 150 miles, respectively; the former nearly due north and the latter nearly due west.

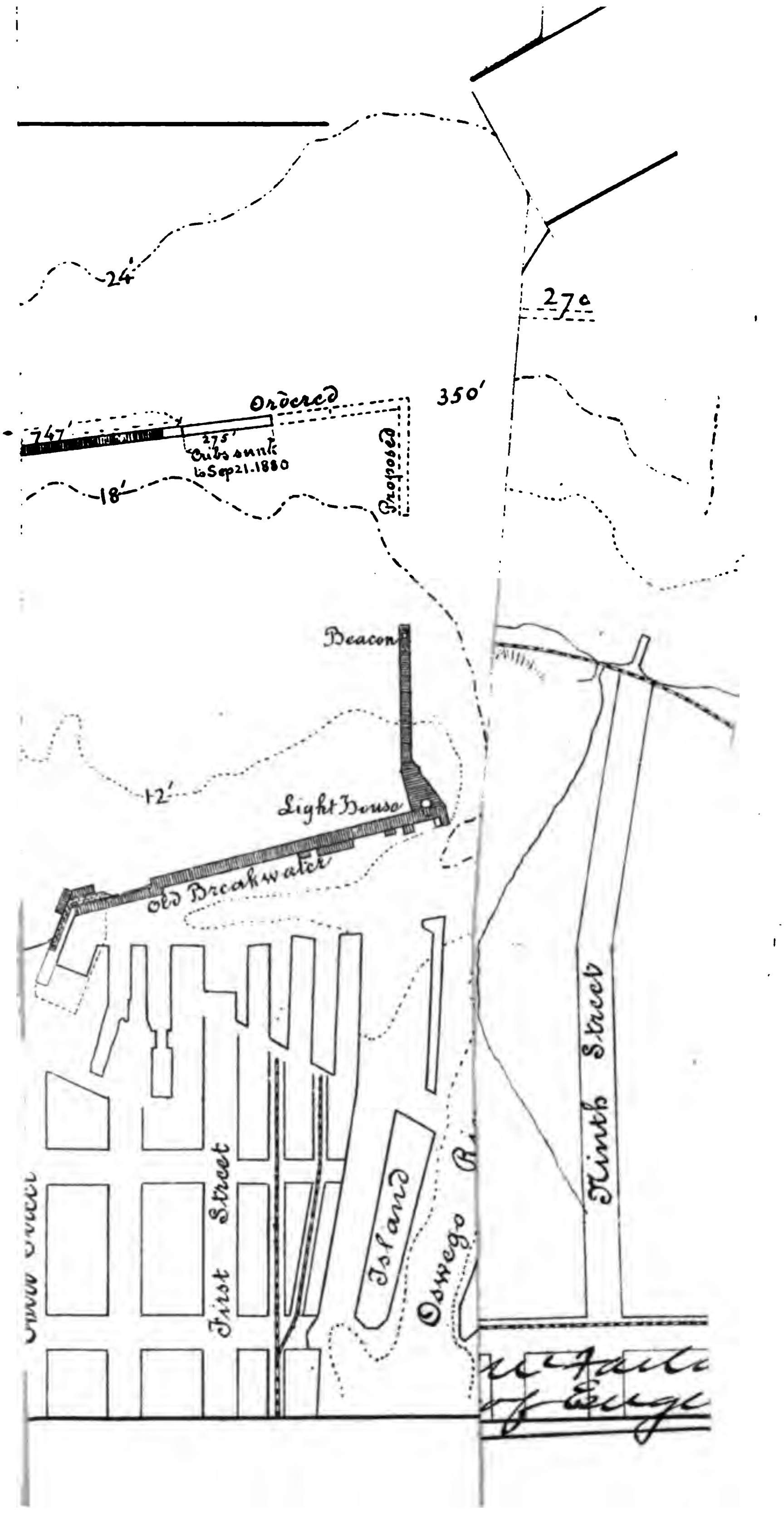
It is at the only outlet of the Erie Canal on Lake Ontario, having by means of it direct water communication with New York.

Before the construction of railroads and canals, the only mode by which freight and passengers reached Lake Ontario from New York was up the Hudson and the Mohawk Rivers to old Fort Stanwix, near where Rome now stands, then by a short portage to Wood Creek, which empties into Oneida Lake, and so on down through Oneida Lake and river and the Oswego River to Oswego and Lake Ontario.

The following statistics of the commerce of this port for the fiscal year ending June 30, 1880, are furnished from the records of the custom-house through the courtesy of the collector of customs:

Revenue from customs	$746,562 99
Value of imports	$5,142,697 00
Value of exports	$786,825 00
Number of vessels cleared	2,371
Their tonnage ... tons	402,563
Number of vessels entered	2,398
Their tonnage ... tons	404,807
Probable number of other vessels arriving and departing	50

Chief articles of commerce: lumber, grain, coal, and merchandise.



24'
27a
Ordered
350'
747'
275'
Cribs sunk to Sep 21.1880
Proposed
18'
Beacon
12'
Light House
Old Breakwater
Island
Oswego
First Street
Ninth Street

Money statement.

July 1, 1879, amount available	$141,784 44	
Amount appropriated by act approved June 14, 1880	90,000 00	
		$231,784 44
July 1, 1880, amount expended during fiscal year		111,094 71
July 1, 1880, amount available		120,689 73
Amount (estimated) required for completion of existing project, construction of east breakwater		287,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		150,000 00

Abstract of proposals for the extension of Oswego Breakwater received and opened at United States Engineer Office, Oswego, N. Y., at 10 *o'clock a. m. November* 29, 1879, *under advertisement of October* 29, 1879.

Number.	Name and address of bidder.	White pine, approximate quantity, 300,000 feet, b. m.	Hemlock, approximate quantity, 850,000 feet, b. m.	Oak, approximate quantity, 25,000 feet., b. m.
1	Syracuse Iron Works, R. N. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson Gere, Geddes, N. Y., Charles E. Hubbell, Geddes, N. Y.			
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio, Daniel R. Taylor, Cleveland, Ohio.			
3	Thomas Hunter, Sterling, Cayuga County, N. Y. Guarantors: Manistee Worts, Oswego, N. Y., N. W. Nutting, Oswego, N. Y.	At $19.50 per 1,000 ft., b. m., $5,850.	At $15.50 per 1,000 ft., b. m., $13,175.	At $40 per 1,000 ft., b. m., $1,000.
4	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio, George W Steele, Painesville, Ohio.	At $16 per 1,000 ft., b. m., $4,800.	At $12 per 1,000 ft., b. m., $10,200.	At $16 per 1,000 ft. b. m., $400.
5	Daniel M. Owen, New York City. Guarantors: John O. Evans, Washington, D. C., John G. Moore, New York City.	At $19 per 1,000 ft., b. m., $5,700.	At $23 per 1,000 ft., b. m., $19,550.	At $30 per 1,000 ft., b. m., $750.
6	George Kellogg, Fulton, Oswego County, N. Y. Guarantors: F. D. Van Wagener, Fulton, N. Y., O. J. Jennings, Fulton, N. Y.	At $24 per 1,000 ft., b. m., $7,200.	At $17 per 1,000 ft., b. m., $14,450.	At $30 per 1,000 ft., b. m., $750.

Number.	Name and address of bidder.	Stone, broken and filling, in place, approximate quantity, 3,000 cords.	Labor on timber, per 1,000 feet, b. m.	Belts, screw and washer, approximate quantity, 6,000 pounds.
1	Syracuse Iron Works, R. N. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson Gere, Geddes, N. Y., Charles E. Hubbell, Geddes, N. Y.	....	....	At 6¼ cents per lb., $375.
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio, Daniel R. Taylor, Cleveland, Ohio.			
3	Thomas Hunter, Sterling, Cayuga County, N. Y. Guarantors: Manistee Worts, Oswego, N. Y., N. W. Nutting, Oswego, N. Y.	At $5.50 per cord, $16,500.	At $8.25 per 1,000 ft., b.m., $9,693.75.	....
4	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio, George W. Steele, Painesville, Ohio.	At $6.50 per cord, $19,500.	At $10 per 1,000 ft., b. m., $11,750.	....
5	Daniel M. Owen, New York City. Guarantors: John O. Evans, Washington, D. C., John G. Moore, New York City.	At $5.50 per cord, $16,500.	At $7 per 1,000 ft., b. m., $8,225.	....
6	George Kellogg, Fulton, Oswego County, N. Y. Guarantors: F. D. Van Wagener, Fulton, N. Y., O. J. Jennings, Fulton, N. Y.	At $8 per cord, $24,000.	At $8.33 per 1,000 ft., b.m., $9,787.75.	....

Abstract of proposals for the extension of Oswego Breakwater, &c.—**Continued.**

Number.	Name and address of bidder.	Bolts, drift, approximate quantity, 100,000 lbs.	Spikes, approximate quantity, 6,000 pounds.	Total.
1	Syracuse Iron Works, R. N. Gere, president, Syracuse, N. Y. Guarantors: R. Nelson Gere, Geddes, N. Y., Charles E. Hubbell, Geddes, N. Y.	At 3$\frac{4}{10}$ cents per lb., $3,400.	At 4$\frac{9}{10}$ cents per lb., $294.	$4,000 00
2	Frank Wilson, Cleveland, Ohio. Guarantors: Aaron M. Wilcox, Cleveland, Ohio, Daniel R. Taylor, Cleveland, Ohio.	....	....	Same prices not given in duplicates.
3	Thomas Hunter, Sterling, Cayuga County, N. Y. Guarantors: Manistee Worts, Oswego, N. Y., N. W. Nutting, Oswego, N. Y.	....	....	$46,218 75
4	Lucius Farris and Alexander H. Garfield, Painesville, Ohio. Guarantors: Richard Tinan, Painesville, Ohio, George W. Steele, Painesville, Ohio.	....	....	46,650 00
5	Daniel M. Owen, New York City. Guarantors: John O. Evans, Washington, D. C., John G. Moore, New York City.	....	....	50,725 00
6	George Kellogg, Fulton, Oswego County, N. Y. Guarantors: F. D. Van Wagener, Fulton, N. Y., O. J. Jennings, Fulton, N. Y.	....	....	56,187 75

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IMPROVEMENT OF OGDENSBURG HARBOR, NEW YORK.

The scheme for the improvement of this harbor which provided for dredging the channel of the Oswegatchie River below the brige, deepening the channels along the Saint Lawrence front of the city and across the bar northeast of the light-house, and constructing a quantity of pile piering to prevent the water of the channels from spreading over the shoal between them, was completed in 1876, so far as the dredging is concerned, and the channels are now in good condition.

The projected pile piering was always regarded as a contingent work; to be constructed if time showed that it was necessary for the preservation of the channel; but this has not yet been shown, and it now seems probable that it will never be needed. The estimated cost of its construction was $70,000; but as it is not a necessary work at present, no money is asked for it.

No money has been expended here during the year, and there are no funds available.

Ogdensburg Harbor, New York, is in the collection district of Oswegatchie, on the Saint Lawrence River, opposite Prescott, Canada, about 100 miles from Oswego and Fort Ontario, and about 60 miles below Cape Vincent, at the outlet of the Saint Lawrence from Lake Ontario. It is lighted by a fixed white light of the fourth order, situated on an island at the south side of the mouth of the Oswegatchie River.

The following statistics of its commerce for the fiscal year ending June

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30, 1880, are furnished from the records of the custom-house through the courtesy of the collector of customs:

Revenue from customs	$184,620 97
Value of imports	$1,311,821 00
Value of exports	$425,150 00
Number of vessels cleared	1,166
Their tonnage ... tons	203,656
Number of vessels entered	1,167
Their tonnage ... tons	203,826
Probable number of other vessels arriving and departing	800

Chief articles of commerce: lumber, grain, and live stock.

Money statement.

Amount (estimated) required for completion of existing project........ $70,000 00

RESURVEY OF OGDENSBURG HARBOR, NEW YORK.

In answer to a letter from the Office of the Chief of Engineers, calling for an estimate for this work, I reported as follows:

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., July 26, 1879.

GENERAL: In answer to your letter of April 25 last, directing me to submit an estimate for the resurvey of Ogdensburg Harbor, New York, I have the honor to report as follows:

A careful survey of this harbor was made by the lake survey, under orders from Maj. C. B. Comstock, Corps of Engineers, in 1871, 1872, and 1873. Since that time the channel has been improved under various acts of Congress, and the authority of the Chief of Engineers; but the changes so made are recorded in this office and in the Office of the Chief of Engineers, and no additional survey is needed on this account.

The waters of the river Saint Lawrence are nearly or quite free from sediment, and the sediment brought down by the Oswegatchie has in no material way affected the harbor of Ogdensburg or the entrance to it, and no survey is necessary on these accounts.

It is presumed that the object of the survey now ordered is to ascertain the practicability and cost of dredging a channel across the bar which lies in front of the city of Ogdensburg, below the channel which now exists at the mouth of the Oswegatchie, as inquiries concerning the construction of such a channel have repeatedly been sent to this office for a number of years back.

To ascertain this nothing more than an examination would be necessary, and such an examination would cost as follows:

Hire of boats, one month	$50
Hire of 4 men, one month, each	120
Hire of assistant engineer, one month	125
Lines, &c	5
Total	300

An actual resurvey of the whole harbor, averaging 1 mile in length by one-half mile in breadth, would cost not less than $1,200.

Very respectfully, your obedient servant,

WALTER MCFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

The amount necessary for the examination being allotted, Assistant Engineer F. T. Hampton was sent to Ogdensburg about the middle of December, 1879, Assistant Engineer Maurice Kingsley, in March, 1880, and Assistant Engineer William P. Judson, in June, 1880, to examine into the condition of the harbor, to ascertain what damage had occurred to its channels since they were last dredged, and to report generally upon its necessities.

These three reports agree in this—that the chief injuries that the channels have received have been caused by the saw-dust and other waste products of the saw-mills that have been thrown into the waters of the Oswegatchie River in spite of local regulations forbidding it; but that a small amount of shoaling has also occurred in the main channel of the Oswegatchie, northeast of the light-house, from natural causes.

There appears to be no good reason why the general government should be called upon to undo the mischief that has resulted from the selfishness of the mill owners and the indifference of the authorities. The channels were in perfectly good condition in 1875, and would have remained so to this day if as much attention had been given to their preservation, by the city of Ogdensburg, as a private individual usually gives to the care of his personal interests.

I furnish, however, an estimate of the probable cost of restoring them to their former condition—giving them 12 feet depth of water, viz:

For dredging 30,000 cubic yards of soft material, at 25 cents per cubic yard..	$7,500
For 20 days' dredging at mouth of Oswegatchie River, at $100 per day......	2,000
Contingiencies, &c.	2,500
Total	12 000

As the reports of the assistant engineers above mentioned contain a good deal of information which may be of interest in considering questions which are likely to arise again concerning the further improvement of this harbor, I give them in full.

REPORT OF MR. F. T. HAMPTON, ASSISTANT ENGINEER.

OSWEGO, N. Y., *December* 23, 1879.

MAJOR: In accordance with your instructions I proceeded to Ogdensburg, on the 16th instant, to make an examination of the harbor at that point. Your instructions to me were:

1st. Examine charts and see where work has been done.

2d. Examine those spots themselves and ascertain whether there has been any shoaling there.

3d. Make inquiry if there has been any shoaling anywhere else, and then take soundings.

4th. Examine the proposed route across the shoal in front of the city, opposite State street, and ascertain the depth of water, nature of bottom, &c., and gather any evidence to be had from disinterested parties as to the necessity of making a channel there, and whether it would probably remain open if made.

On December 17 I organized a small party and began taking soundings on the shoal northeast of light-house, known locally as the "Outer Bar." In the afternoon the sea was so heavy as to force me to abandon the work. On the 18th the harbor was frozen 1¼ inches thick, nearly ¼ mile out. By noon the ice was broken up and moved away, but along the city front, and in the Oswegatchie, the ice made it impossible to do anything. I so advised you and recommended the examination of the harbor be postponed till the ice formed over it for the winter, when the survey could be made on the ice. On the 20th instant I returned to Oswego as ordered by your dispatch.

Although I could do nothing in the field, I tried to collect such information as might be serviceable to you in case you have to consider the subject of improving Ogdensburg Harbor before a survey can be made of it.

To enable me to take soundings in the channel in front of the city, Captain Russell, of the ferry-boat Armstrong, steamed slowly through the ice while I took soundings from his boat. I have laid down a few of these soundings on the accompanying map. The least depth I found was 8¾ feet, and this was only for a short distance. The stage of water at the time was 7 feet below top of door-sill east side of light-house tower, the same bench-mark referred to by the chart of June 30, 1875, in your office; the low-water stage being 6.75 feet below this mark.

Where I have written "dredging" in red this work is *badly* needed, though more or less of it is required the whole length of the city front. All the river men with whom I have spoken are unanimous in this opinion. They also want the point of the bar, shown by red line, to be deepened and the old crib work removed. Upon other points I find a variance of opinion. Some desire a further dredging of the "outer bar," par-

ticularly the east side of the channel, to enable sailing vessels to enter it more easily, while by many this part of the channel is considered good enough. The least depth I found on this bar, or more properly gap, was 9½ feet. I got sixty soundings upon it before driven in by the sea, ranging from 9½ to 13 feet. Upon the subject of the proposed new ferry route across the shoal, I could find no disinterested person. The majority I talked with were strongly in favor of it, while a few violently opposed it. I cannot, however, resist the opinion that, so far as the prime movers are concerned, it is a rivalry among property owners. It would be a desirable improvement, but it is not absolutely necessary to the importance of the harbor.

The best informed persons I interviewed were Mr. Roseel, a retired merchant; Judge James, member of Congress from that district; Mr. Giers, one of the leading business men and in charge of express office; Mr. Lyons, a large property owner and interested in present town ferry; Mr. Derby, a railroad official and former commissioner of public works of county. I also saw Mr. Daly, a former contractor on work in this harbor, and various other business and river men.

The principal argument which the friends of the scheme offer are—

It would be free from ice the *entire* year.

It would be the means of uniting the three railroads running into Ogdensburg in a *union* depot.

It would greatly promote the growth of the city.

There is no doubt that at *certain* times the new ferry line would be less obstructed by ice than the present one, there being a stronger current to take the ice away when broken up. But this current would fail to move the ice when a north or northeast wind is blowing. The ice would then bank upon the shoal. I saw this occur. If it should become necessary to use any pile protection on upper side of the trench to prevent its filling up, then the current relied upon to move the ice would be greatly diminished or destroyed.

As a proof of their theory the advocates of this scheme pointed out to me that there was no ice during the recent freeze just below the shoal. Another fact perhaps ought to be here considered. At the time of my visit the waters of the Oswegatchie were *colder* than those of the Saint Lawrence. I noticed that the ice extended out as far as the dark waters of the Oswegatchie could be distinguished before the freeze. I found by measurement, temperature of Oswegatchie 32°, Saint Lawrence 35°. Below the shoal the former stream is lost in the latter, and no ice could form at that point at time of my observation, the water being above freezing point. Should the ferry line across the shoal be opened, I believe this obstruction by ice will be a serious difficulty, and the principal object of its establishment, viz, to give certain communication with the Canadian bank in *winter*, will be a failure. When northern or northeastern winds prevail, it will have no advantage over the present route.

There are three railroads running into Ogdensburg. The Ogdensburg and Lake Champlain Railroad from the east; Utica and Black River Railroad from the south; and Rome, Watertown and Ogdensburg Railroad from the west.

So far there has been no co-operation among these roads for common good, not even enough to secure a connection of their depots by rail.

The map represents a track crossing the Oswegatchie below the bridge and skirting the river front, but there is no such track. It is proposed in the event the new ferry is created that the "Union Depot" would be located on the block I have marked D. Two of these railroads, the Ogdensburg and Lake Champlain, and Rome, Watertown and Ogdensburg Railroad, have slips and ferries of their own, and the Utica and Black River Railroad is contemplating the building of a dock extending from the light-house point, about 1,000 feet, out to deep water, where it is thought ferriage will not be obstructed by ice at any time.

The ferry line of the Ogdensburg and Lake Champlain road is *always open*. This road is very independent in its relations with the other roads. While it would not oppose, it would not encourage the new ferry project. It has a good ferry of its own, and during a portion of the winter has a monopoly of the trade with the Grand Trunk Railroad on Canadian side.

It is by no means certain, therefore, that the opening of this new ferry line will lead to the establishment of a union depot. This arrangement would have been long ago entered into if the interests of all the roads demanded it.

In the absence of a survey of this line over the shoal, I can only say that from all the evidence I can procure it would not be difficult to dredge such a channel. I find the opinion quite common that the bar forming the shoal is not a sedimentary formation from the Oswegatchie River, but is of a similar formation as the adjacent banks of mainland.

Mr. James informed me that he had seen a very old map* on which an island was represented at the mouth of Oswegatchie River.

* The old map of Ogdensburg referred to is dated 1749, and may be found at page 430, Volume I, Documentary History of the State of New York.—WILLIAM P. JUDSON.

Mr. Daly, a former contractor on this harbor, says he dredged the bar at foot of State street to test its nature, and found the first 2 feet in depth composed of sand and gravel and the next 6 feet of *white clay*.

The friends of this project profess great belief in the permanency of the work when once done. They claim it will not fill up. On this point I tried to get some information. I learn that sand has accumulated on the lower side of an old wreck on the shoal, and it is not *all* sawdust that shoals up the channel in front of the city.

To settle this question of the liability of the proposed channel to silt up, before any large amount of money is expended, the friends of the project seem willing to abide by the results of an experiment. They propose that an experimental trench be dug at foot of State street on the line of the proposed channel about 300 feet long. If the cross-section of this prism is much altered in the course of a year, this question of a channel across the shoal would no longer be agitated.

The sawdust nuisance continues, and there is general complaint of it by the owners of docks in lower part of town. The men who own the saw-mills have money and influence, and no city official is willing to incur their displeasure by enforcing the city ordinance prohibiting the throwing of the waste material of the mills into the river.

The proprietors of the docks along the lower city front offer as a final argument for the new ferry line that it would give them an outlet to the Saint Lawrence, from which they are now threatened to be cut off by the sawdust of their neighbors above.

Very respectfully, your obedient servant,

F. T. HAMPTON.

Maj. WALTER MCFARLAND,
Corps of Engineers, U. S. A.

REPORT OF MR. MAURICE KINGSLEY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., March 25, 1880.

MAJOR: In accordance with your verbal instructions of March 13, I went to Ogdensburg and made an examination of the harbor, but on account of running ice was unable to examine the shoal spot on the "outer bar" mentioned in your letter of March 18.

Mr. George Hall, who has the contract for setting out buoys at Ogdensburg, expects to do it in the middle of April. This would be the best time for making the examination, and I therefore asked him to notify you when he did it.

I took soundings in the Oswegatchie channel for about 1,000 feet below the bridge and found that no material change had taken place since the soundings taken in 1875, when the last dredging was done; but just opposite the Rome, Watertown and Ogdensburg Railroad Depot there are some large bowlders, with 10 to 11 feet of water over them at low-water.

At the east end of Ogdensburg, along the docks of the Lake Champlain Railroad and Northern Transportation Company, I also took soundings and could find no material change since the soundings taken in 1875, except in the slips and close to the face of the wharves, where sawdust from the Oswegatchie has accumulated. This, however, is inside the line of the channel proper, and is a matter for the railroad company to attend to.

The only part of the harbor which shows change is the channel along the city front from the Oswegatchie channel up to the Northern Transportation docks, especially the western end.

This channel was dredged by the end of 1875 to 12 feet in depth for 150 feet wide. Now, there is a 12-foot channel throughout the whole length, but the original channel has so filled up with sawdust and shavings from the Oswegatchie that I do not believe it would average 40 feet in width with a depth of 12 feet. The principal shoaling is on the south side of the channel and up in the slips and docks.

For a number of years the saw-mills, some four in number, situated above the bridge, have been accustomed to put all their refuse of sawdust, shavings, ends of logs and slabs into the Oswegatchie, and I find constant references to this in the records of this office, both in reports and in letters to Ogdensburg officials.

A few years ago suit was brought against the mill owners and a judgment of $500 obtained, but through the laxity of officials it was never collected. I was told that this judgment stopped the abuse more or less for the time, but that within a year it had been as bad as ever.

Now, as by the end of 1875, the government had given the city of Ogdensburg a 12-foot channel 150 feet wide along the city front, and as by the laxity of the city officials it has since filled up, not by sand or matter from the river, but from the refuse from the mills, I cannot see why the government should be required to spend more

money on this part of the harbor. And also this channel has been very rarely used and very rarely will be. The business of Ogdensburg centers around the mouth of the Oswegatchie on the west and at the Lake Champlain Railroad on the east, the latter point doing the very much larger business.

The class of business at each point is different, each has its channel and ferry leading to and from it.

The union depot spoken of in Mr. Hampton's report of December 17, 1879, is never likely to be built, judging from what the superintendents of the three railroads leading into Ogdensburg told me, and I consider their views much more valuable than those of the real estate owners who are now and have been agitating the matter.

The union ferry leading from it across the bar is a scheme of the same sort, and I found that the most practical men in Ogdensburg fully agreed with Mr. Hampton and myself that such a channel would not keep open so long as the other two in winter.

The question was taken up by Major Wilson, in a letter to the department dated October 23, 1874, but I think that though the dike he speaks of for the upper side of the channel would perhaps save the channel from filling in, it would give the ice a foothold in an east wind which in one night would prevent the ferry-boats cutting through.

PILE PIERING AS PROPOSED BY THE BOARD OF ENGINEERS IN 1868.

The report of this Board is found on page 270 of the Report of Chief of Engineers for 1868, and in it there is the following:

The indications as afforded by the velocities of the currents and the nature of the bottom make it probable that the inshore channel, after being dredged to a depth of 12 feet, will gradually fill up, and *should this be the case* a concave pier, the position and extent of which is given on the accompanying map, would have the effect to maintain the proper depth.

Major Wilson, in a report or rather letter to the Department dated October 6, 1874, on this subject, says: "Were it not for this (the filling in of the channel by sawdust and shavings) I do not deem the piers necessary."

The channel as dredged in 1875 now remains good, but for the filling in of sawdust, &c., from the mills, which has been allowed by Ogdensburg officials; and it does not seem just to make the general government spend money on a pile piering when it really is not necessary.

On the inclosed tracing of the map on which the Board of Engineers based their report of June, 1868, there are six lines of current shown from the Oswegatchie by red arrows.

It was the general opinion of persons from whom I made inquiry at Ogdensburg that the lines of current from the Oswegatchie had changed materially since opening the 150-foot channel along the city front to 12 feet in depth; and that whereas before that the Oswegatchie current was traceable in certain winds all over the shoal on the east side of the light-house channel, that now the current never shows north of the light-house, and that it generally hugs the south shore in and close to the 150-foot dredged channel along the city front. During the four days I was in Ogdensburg the wind happened to blow from every point of the compass, and at no time could I trace the Oswegatchie water (which is very dark, while that of the Saint Lawrence is clear) beyond (north of) the line I have marked by blue arrows on the map of 1868. It would seem, then, that the condition of the currents of 1868, upon which the Board of Engineers based their report, has changed, and in itself makes the pile piering unnecessary. Their proposition to protect the channels by pile piering was contingent upon the channels filling up with sand, &c., from the shoal. The only filling in has been from sawdust, &c. Therefore it would seem even that the contingency itself has not arrived, unless the Board of Engineers meant the contingency of the channel filling in by sawdust.

Another argument against this pile piering is the lodging of ice on it in winter. No mention of this is made in the report of the Board of Engineers, but I cannot help believing that floe ice would lodge on the light-house channel pier so as to block the channel entirely during winter.

The Utica and Black River Railroad expect to build this year a pier and steamboat wharf from their depot out into the deep water of the Saint Lawrence at the back (west) of the light-house. This must have quite an effect upon the light-house channel, and I thought it worth while to call your attention to it.

To sum up, with the exception of the outer bar and the channel along the city front, no material change has taken place in the channels since 1875, when the improvement was considered finished.

Of the cost of the first I can make no estimate till further soundings are made. The second is purely a matter for Ogdensburg to take up. And I would respectfully suggest that if any money is appropriated for Ogdensburg it be applied first to the dredging of the outer bar, and the balance to improving the channel from the south end of the

Rome, Watertown and Ogdensburg Railroad Wharf northward by excavating the bowlders to 13 feet in depth, which would require the excavation of—

1,500 cubic yards of hard material, at $3 per yard	$4,500
Contingencies, 25 per cent	1,125
Total	5,625

Respectfully submitted.

MAURICE KINGSLEY,
Assistant Engineer.

Maj. WALTER MCFARLAND, *Corps of Engineers, U. S. A.*

REPORT OF MR. WILLIAM P. JUDSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., June 12, 1880.

MAJOR: I have the honor to submit the following report upon the condition of Ogdensburg Harbor, based upon a survey made between April 21 and 28, in obedience to your order of April 19, 1880:

The last complete survey was made in June, 1875, and this survey was ordered to ascertain if any change had occurred since then. During September–December, 1875, dredging was done upon the Light-House Bar and in the United States channel along the Saint Lawrence front of the city, from the Oswegatchie outlet to the Northern Transportation Company Elevator. This work was not shown upon the map.

Upon the Light-House Bar the work consisted of removing a shoal of 100 feet diameter with 11 feet depth, which had formed in the center of the channel.

This shoal has again formed at the same point, with 11 feet and over depth and with the same area as before.

With this exception there is a channel across the Light-House Bar 200 feet and over wide and with 12 feet and over depth at low-water.

The bowlders, stone, gravel, and clay, which are here deposited, come from the shoal above the light-house, being picked up by grounded ice floes, floated past the Light-House Point and dropped in the meeting of the Saint Lawrence with the Oswegatchie current.

The amount to be removed to perfect a 200-foot channel, with 12 feet depth at low-water, is 500 yards in position.

Next in importance to commercial interests are minor obstructions in the mouth of the Oswegatchie between the Rome, Watertown, and Ogdensburg Railroad Wharf and the bridge; these consist of isolated bowlders which are scattered over the otherwise level bottom of the river. These are all located upon the map, and number about 50; they vary from 1 to 2 cubic feet each, excepting one which contains about 2 cubic yards. This, with a dozen other smaller ones, are old obstructions. The remainder have recently been brought by the ice from the shallows, 200 yards up the Oswegatchie.

Another minor obstruction, which has caused more annoyance than any other, is the remains of a 4-yard scow load of building stone which was dumped two years ago on the edge of the United States Channel, 50 feet out from Nevin's Wharf. The owner, Mr. Nevin, has taken out a few of the stone, leaving a pile of 3 cubic yards over which is only 6½ feet depth at low-water.

The most important portion of the harbor work has been the United States Channel along the Saint Lawrence front of the city, from the Oswegatchie outlet to the Northern Transportation Company Elevator Wharf, and the most marked change in the harbor since 1875, has been the shoaling of this channel. But this shoaling has not yet progressed so far as to be an obstruction to navigation.

The present condition of this channel, with the changes, are shown in the following table: The channel has a width of 150 feet and a length of 5,200 feet from the Oswegatchie outlet to the northeast angle of the Northern Transportation Company Wharf; not including the extension of the channel around the angle and past the Northern Transportation Company freight-house to the elevator.

Distance from Oswegatchie.	Shoaling since 1875.	Present depth, low-water.	Present width.
	Feet.	*Feet.*	*Feet.*
0 to 700 feet	1	10½ to 12½	200 to 140
At 700 feet	1½	10½	140
700 to 1,300 feet	1½ to 0½	10½ to 11½	140 to 150
1,300 to 3,000 feet	1½	10½ to 11½	150
3,000 to 4,600 feet	1	12	150
4,600 to 5,200 feet	1	12 to 12½	150

This shoaling has been caused by the continued deposit of sawdust, &c., in the Oswegatchie current by the owners of four saw and shingle mills above the bridge, who still so dispose of their waste, despite the ineffectual attempts of the city government to enforce the eminently just laws which should prevent such action.

This shoaling is now at its minimum, the sawdust having been swept out by the spring freshets. It will doubtless accumulate during the low-water of summer until the fall rains shall again raise the Oswegatchie current.

As shown by the current measurements of this survey, the entire Oswegatchie flow now passes through the United States Channel, thus making unnecessary the pile pier which was projected some years since for this end.

The city officers of Ogdensburg evidently lack the nerve to enforce the harbor laws. If the officer in charge should see fit to aid them by refusing to do further work until the ordinance is enforced, and should thus relieve the city officers from the hostility of the sawdust interest, which would result from prosecution, I think that such action would be effective.

I submit herewith an estimate of cost of work to restore the channels to their condition in 1875, when the harbor was considered complete.

For dredging 30,000 cubic yards (*in situ*) soft material, at 25 cents	$7,500
For 10 days' work of dredge in mouth of Oswegatchie, at $100	1,000
For contingencies, superintendence, &c., 25 per centum	2,125
Total	10,625

Very respectfully, your obedient servant,

WILLIAM P. JUDSON.
Assistant Engineer.

Maj. WALTER MCFARLAND,
Corps of Engineers, U. S. A.

J J 12.

IMPROVEMENT OF WADDINGTON HARBOR, NEW YORK.

By the river and harbor act, approved June 18, 1878, an appropriation of $5,000 was made for the improvement of this harbor.

As explained in my last annual report, the delay that has occurred in the expenditure of this appropriation, was due to a doubt as to where it should be applied; the appropriation having been made in the absence of any previous survey or report calling for it. This question having been finally settled, proposals were called for by public advertisement, dated October 29, 1879. The work to be done as described in the specifications of the same date, being the excavation of a channel through the rocky bed of the river, from James' Mill to the deep water below.

The bids were opened November 29, and resulted in the award of the work to Cornelius Daly, of Ogdensburg, who signed the articles of agreement January 17, 1880, agreeing to do the work at 50 cents per cubic yard for the material which he would not have to blast, and for $5.00 per cubic yard for material that he would have to blast; the measurements to be made in position, and the contract to be finished June 30, 1880. At that date, however, only about 2,200 cubic yards of soft material that did not require blasting, had been removed from the channel by him, he having failed to finish his contract.

Just before the close of the fiscal year he applied for an extension of time, for the completion of this contract, to November 30, 1880, which, on my recommendation, was granted by the Chief of Engineers, under date of July 2. Notification of this extension was sent Mr. Daly July 7, with forms of agreement for himself and his sureties to sign, accepting the extension and continuing the bonds. The agreement was signed by Mr. Daly and returned to this office, but the sureties' agreement, al-

though repeatedly called for, has never been returned; and the contractor has removed his dredge, thus abandoning the work.

The balance of the old appropriation, and the appropriation of $3,000 made by act approved June 14, 1880, will be applied to the improvement of the channel below the dam.

The present scheme for the improvement of this harbor was made in consequence of the appropriation of June 18, 1878, and provided for deepening the lower channel, which extends up stream to the mills below the dam. The original estimate provided for the removal of about 6,000 cubic yards of rock, at $2.50 per cubic yard. This price was based upon the belief that the rock to be removed was of the same character as that which had previously been removed, which could in many cases be torn up by the dredge with little or no blasting.

Experiment, however, shows that the rock is very hard Laurentian limestone, that requires a great deal of drilling and blasting, and that it will probably cost twice as much as the original estimate, or at least $5 per cubic yard, to remove it, which would increase the estimate for the completion of this work $15,000, making the amount yet needed to complete it $22,000.

The appropriation of $7,000 called for is for the continuation of this work.

The present condition of this harbor is shown by the map which accompanied my last year's report upon it.

Waddington Harbor, New York, is in the collection district of Oswegatchie, on the Saint Lawrence River, about 20 miles below Ogdensburg, where the nearest American light-house is situated, and about 90 miles in a straight line from Fort Montgomery, at Rouse's Point, on the outlet from Lake Champlain.

The following statistics of its commerce for the fiscal year ending June 30, 1880, are furnished from the records of the custom-house, through the courtesy of the collector of customs at Ogdensburg:

Revenue from customs	$9,212 15
Value of imports	$70,238 00
Value of exports	$20,500 00
Number of vessels cleared	20
Their tonnage ... tons	1,000
Number of vessels entered	20
Their tonnage ... tons	1,000
Number of arrivals and departures independent of those entering and clearing	100

Chief articles of commerce: live stock, raw hides, rags, and eggs.

Money statement.

July 1, 1879, amount available	$4,869 48	
Amount appropriated by act approved June 14, 1880	3,000 00	
		$7,869 48
July 1, 1880, amount expended during fiscal year	1,731 62	
July 1, 1880, outstanding liabilities	330 86	
		2,062 48
July 1, 1880, amount available		5,807 00
Amount (estimated) required for completion of existing project		22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		7,000 00

Abstract of proposals for dredging at Waddington Harbor, New York, received and opened at United States Engineer Office, Oswego, N. Y., at 10 o'clock a. m., November 29, 1879, under advertisement of October 29, 1879.

Number.	Name and address of bidder.	With blasting, approximate quantity, 1,000 cubic yards.	Without blasting, approximate quantity, 1,500 cubic yards.	Total.
1	Cornelius Daly, Ogdensburg, N. Y. Guarantors: Walter B. Allen, Ogdensburg, N. Y.; Daniel Magone, Ogdensburg, N. Y.	At $5 per cubic yard, $5,000.	At 50 cents per cubic yard, $750.	$5, 750
2	George Kellogg, Fulton, N. Y. Guarantors: F. D. Van Wagenen, Fulton, N. Y.; O. J. Jennings, Fulton, N. Y.	At $8 per cubic yard, $8,000.	At $5 per cubic yard, $7,500.	15, 500

Abstract of contract for improving harbor at Waddington, New York, entered into during the fiscal year ending June 30, 1880.

Name of contractor.	Sureties.	Material.	Price.
Cornelius Daly, of Ogdensburg, N. Y.	Walter B. Allen, of Ogdensburg, N. Y.; Daniel Magone, of Ogdensburg, N. Y.	Dredging, with blasting... Dredging, without blasting	$5 per cubic yard. 50 cents per cubic yard.

Contract entered into January 17, 1880; expires June 30, 1880.

APPENDIX K K.

IMPROVEMENT OF OAKLAND AND WILMINGTON HARBORS AND OF SACRAMENTO RIVER AND PETALUMA CREEK, CALIFORNIA.

REPORT OF LIEUT. COL. GEORGE H. MENDELL, CORPS OF ENGINEERS, BVT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 13, 1880.

GENERAL: I have the honor to transmit the annual reports of the river and harbor works under my charge for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

G. H. MENDELL,
Lieutenant-Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

K K 1.

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA.

The river and harbor act of March 3, 1879, appropriated $60,000 for the improvement of this harbor, subject to the restriction that no part of it should be expended until the title to the bed of the estuary and the sites of the training walls should be obtained free of expense to the United States. This act contained the further provision that unless this result was arrived at by 1st of September, 1879, the sum appropriated should be returned to the Treasury.

Every effort was made by this office to bring the negotiations with the Oakland Water Front Company to such a result as would save this appropriation to the work and permit the construction to go on.

These negotiations were unsuccessful, and as a consequence the appropriation of $60,000 was lost to the work.

The last phase of this controversy with the Oakland Water Front Company, which has been the cause of the suspension of work on the harbor for the past two years, is that the legal question has been submitted by the War Department to the Attorney-General for his opinion.

The only other party to this controversy is the city of Oakland. On the 20th of August, 1879, the council of Oakland passed an ordinance releasing to the United States all of the water front belonging to the city; namely, that portion included between the westerly line of Franklin street and the easterly line of Webster street.

The operations of the past year have been confined to the preparation of maps and other papers in the office bearing upon the negotiations

above referred to, and to a supervision of dredging operations in the harbor, carried on by private parties. This supervision is maintained in order that the material dredged may be deposited where it will do the least injury to navigable channels.

CONDITION OF THE IMPROVEMENT.

The work done upon this harbor consists in two stone jetties extended from the shore into the Bay of San Francisco over a sandy bottom, and in a certain amount of dredging between these jetties. These works have resulted in giving a channel 200 feet wide and 10 feet in depth. Before the work was commenced the depth did not exceed 5 feet. The result of the improvement of the channel is a large increase in the commerce of the city, which is illustrated in the commercial statistics accompanying this report and previous annual reports.

The project for this harbor contemplates a ship channel of about 20 feet at low-water, to which the tide will add, at different stages, 4 to 8 feet.

The original estimate for the completion of the work was	$1,335,435 20
Amount appropriated to date	415,000 00
Amount expended to date	261,599 85

FUTURE OPERATIONS.

The first step in continuing this improvement will be in raising the north jetty to high-water mark for a distance of 6,400 feet, beginning at the shore. The south jetty will also be raised to the same level for a distance of 7,750 feet. The level of the tops of these walls is now about 4 feet below high-water mark. The foundation is now well settled, and will bear the superstructure, which will be made of rubble stone several hundred pounds weight.

As soon as this work is well under way it will be expedient to widen the channel by dredging to 300 feet, thus adding 100 feet to the width. It is possible that it may be expedient to increase the depth as well as the width.

The jetties, being brought to high-water mark for a considerable portion of their length, will conserve the channel that is secured by dredging. Indeed, these jetties may be made the instrument of excavating the channel, but it is doubtful whether this course would be advantageous. The material removed by the scouring action of the water would be deposited elsewhere outside the jetties, and would have to be moved again by artificial means. An increase in the capacity of the channel is made necessary by the extent and character of the commerce. Six large ferry-boats are, or have been, employed in carrying passengers and freight, and they pass at intervals of 10 minutes. These boats are 300 feet long and have a beam of about 80 feet, and to pass each other in a channel of 200 feet in width is far from convenient.

The channel between the jetties having been made of sufficient capacity for present need, and its conservation having been provided for by the raising of the jetties, the next step of the work will be to lay the foundation for a still greater channel capacity by excavating the tidal basin at the head of the harbor.

It is estimated that the funds now available will be sufficient for the work already described on and between the jetties, and that the next appropriation will be devoted to the excavation of the basin for the purpose of increasing the tidal prism of the harbor.

The last annual report mentioned the fact that the city of Oakland expects to pay for the land necessary to be acquired for a canal, included in the original project, to connect San Leandro Bay with Oakland Harbor. Condemnation proceedings were commenced by the United States nearly two years ago in a State court. The matter got into the United States court more than a year ago under an application of one of the defendants, which had the effect to suspend the condemnation proceedings.

No information has been received during the past year as to the prospect of a result under these proceedings.

STATISTICS.

Attention is invited to the accompanying statements of trade concerned with this improvement:

Oakland Harbor is in the customs district of San Francisco. The amount of duties collected during the fiscal year just past is $5,614,749.64. The nearest port of entry to this harbor is San Francisco, distant 7 miles by water, and has a safe and direct communication throughout the year. The nearest forts are those in San Francisco Bay.

Money statement.

July 1, 1879, amount available	$155, 941 74	
Amount appropriated by act approved June 14, 1880	60, 000 00	
		$215, 941 74
July 1, 1880, amount expended during fiscal year		2, 541 59
July 1, 1880, amount available		213, 400 15
Amount (estimated) required for completion of existing project		920, 435 20
Amount that can be profitably expended in fiscal year ending June 30, 1882.		150, 000 00

COMMERCIAL STATISTICS.

Oakland Harbor, 1879.

Calendar years.	Number of passengers.	Oakland ferries.
1879	5, 562, 889	Central Pacific Railroad line.
1879	527, 491	South Pacific Coast Railroad line.
Total	6, 090, 380	
Same, total 1878	5, 853, 219	

General wharf report.

Number of wharf.	Number of vessels.	Registered tons.	Tons freight.	
1	56	16, 800	18, 000	Market-street wharf.
2	40	5, 000	8, 000	Clay-street wharf.
3	41	8, 400	10, 000	Washington-street wharf.
4			89, 350	Broadway wharf.
5	291	22, 160	24, 277	Franklin-street wharf.
6	343	40, 398	60, 000	City wharf.
7	38	1, 367	2, 000	Anderson's wharf.
8	Failed	to report		La Rue's wharf.
9			17, 693	Alameda Railroad ferry landing.
10			490, 800	New Oakland freight ferry.
Totals	809	94, 125	720, 120	
Totals 1878	1, 705	162, 520	290, 821	

Long Wharf, ferry landing.

	1878.	1879.
Number of vessels arriving	86	492
Centals grain exported	3,014,256	2,162,640
Tons freight (local)	200,000	222,347

Port of San Francisco.

	1878.	1879.
Number of vessels entered	645	635
Number of vessels cleared	676	669
Customs revenues	$6,370,618	$7,643,572
Imports, merchandise and treasure	$75,261,553	$68,248,834
Exports, merchandise and treasure	$66,678,026	$62,782,500

K K 2.

IMPROVEMENT OF WILMINGTON HARBOR, CALIFORNIA.

The operations of the past year consisted in the placing of stone on the lines of the different jetties of the harbor. Four thousand four hundred and eighty-three tons were purchased and applied mainly to the protection of the double timber jetty. Four thousand one hundred and thirty-four tons were thus used. The remainder was mainly deposited on the west jetty. The outside of the double timber jetty was protected throughout its length, which is 1,000 feet, except for a distanceof 90 feet.

FUTURE OPERATIONS.

The money available for the coming year's operations will be applied to making a cut in the reef at the entrance of the harbor, so as to increase the width of the channel from 150 to 200 or more feet. It is hoped that the money will be sufficient to make this width 225 feet. An advertisement has been prepared with the view to giving a contract for the dredging, and if everything goes on well this cut will be made by close of the present year.

The appropriation asked in this report closes the improvement. In 1876 an estimate of $100,000 was made for the completion of the work. Of this sum $67,000 have been appropriated, leaving $33,000 to be provided. It is desirable that this sum be appropriated at the next session of Congress. This will be applied to stone-work in raising the main and west jetty, and to protecting the timber line where the sand has not accumulated in sufficient quantity to afford protection.

THE COMMERCE OF THE HARBOR.

The exports of the year 1879 were 11,740 tons. The imports were 24,057 tons, and 27,194,208 feet of lumber and railroad ties.

There is a noticeable increase over the year 1878. It is expected that the coming year will show a large export of cereals, the crops having turned out very favorably.

The arrivals in 1879 were as follows:

	Ships.	Barks.	Brigs.	Schooners.	Steamers.
Arrived in 1879	2	18	3	136	194
Entered the harbor	......	8	3	136	81

The larger classes of vessels draw too much water to enter the harbor, and therefore remain at anchor in the Bay of San Pedro. The deepest draught carried into the harbor during the year was the bark Sierra Nevada, drawing something over 15 feet.

A wharf has been constructed during the year in the lower part of the harbor, which, being accessible to vessels entering, will help to make the benefits of this improvement felt by the agricultural and commercial interests of the neighborhood.

Wilmington is a port of delivery in the customs district of San Diego. Its foreign imports are mainly coal. The amount of duties collected during the past fiscal year was $20,451.96. The nearest fortification is at San Diego, 80 miles distant, and the nearest light-house is at Point Fermin, close to the entrance of the harbor.

THE PRESENT CONDITION OF THE HARBOR.

The channel was sounded at the close of the fiscal year. The hydrography shows about the same depth as last year, there being however a little improvement. The depth of the channel is now a couple of inches short of 10 feet. The extent of dunes remains essentially unchanged.

There is a wreck of a bark within 60 feet of the channel in the foreshore of Deadman's Island and close to the entrance. The loss occurred last winter during a gale on the attempt to enter the channel at night. This wreck is now not a danger; perhaps it may become one in the future.

The sum of $33,000 can be profitably applied in the coming year.

The amount expended to date is $487,200.00.

Money statement.

July 1, 1879, amount available	$13,977 60	
Amount appropriated by act approved June 14, 1880	35,000 00	
		$48,977 60
July 1, 1880, amount expended during fiscal year		13,927 60
July 1, 1880, amount available		35,050 00
Amount (estimated) required for completion of existing project		33,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		33,000 00

K K 3.

IMPROVEMENT OF THE SACRAMENTO RIVER, CALIFORNIA.

OPERATIONS DURING THE YEAR.

Bids were opened on the 5th of July for the removal of snags in the Sacramento, and in consequence a contract was made with S. D. Stevens

on the 9th of July at the rate of $39.50 per snag. He began work on the 27th of July and completed it on September 20, having removed 132 snags. The effect of this work was to give fair navigation as far as McIntosh's Landing, which has been for some years the actual head of navigation.

In February this office was informed that the navigation of the river was very much obstructed near Jacinto by snags which had been brought into the river by a freshet in the preceding month. One or more wheat barges had been injured by collision with the snags. An arrangement was made with Joseph Emerick for the removal of these obstructions under the supervision of an inspector. Twenty-two snags were removed at a cost of $45 each; 16 of these were destroyed at an additional cost of $10 each. The total cost was $1,150.

It has been intended to devote the remainder of the appropriation of March 3, 1879, to the construction of wing-dams in the lower river, but the necessity for this improvement was not so pressing as the demands of the navigation interests in the upper river in the summer when the wheat crop begins to move.

Inasmuch as the appropriation for the year 1880 promised to be too late to be of service in clearing the river of snags in this season, it was thought best to reserve the remainder of the appropriation for the clearance of snags in the summer of 1880.

After advertisement, bids were opened on the 22d of June, 1880, and in consequence a contract was made the same day for the removal and destruction of snags at the rate of $55 per snag.

This is the first year that the destruction of snags has been provided for. Hitherto they have been simply removed. The operations thus contracted will begin in the first week in July.

Another new point included in this contract is the clearance of the river above Sam Soule's bar, which, in connection with a dam yet to be mentioned and yet to be built, will add 20 miles to the length of the navigable river and facilitate the transportation of the products of an agricultural country of considerable extent.

It is estimated that the funds remaining from the appropriation of March 3, 1879, will be sufficient to pay for the snagging operations; but of this it is impossible to be certain.

FUTURE OPERATIONS.

The act of June 4, 1880, contains an appropriation of $45,000 for this river. This sum will be applied to the following objects:

First. To the construction of a snag-boat, the estimated cost of which is $30,000.

Secondly. To the construction of a barge to act as a tender to the steamer, to carry her supply of fuel and an equipment for building dams.

Thirdly. To the construction of a number of brush dams in the upper river, both above and below Sam Soule's Rapids, beginning a system of making and maintaining 3 feet of water at the low stage below the present head of navigation at Sam Soule's Rapids and 2 feet above that point.

When this is accomplished the wheat barges will carry quite 500 tons on the greater of these depths and about 250 tons on the lesser. There is no special difficulty in acquiring and maintaining these depths. There is plenty of water in the river to give these depths, but inasmuch as the channel changes from year to year, from causes beyond our control at any reasonable expense, it will be necessary to renew these dams as occasion requires. No system of permanent constructions is therefore

possible. The proper treatment is one of annual attention, directed to the correction of evils as they show themselves. This correction, which is generally the concentration of scattered water, can be readily and cheaply accomplished by the construction of brush dams, the materials for which are found in great abundance along the banks of the river. When this shoaling takes place the correction ought to be applied at once. There is therefore no time for advertising as required by the contract system. The occasion for the improvement will generally have passed before the contract could be made and the work executed. It will be necessary to keep the snag-boat employed as a police-boat to put the upper river in good order during the low-water stage.

In addition to clearing the Sacramento River, it is supposed that this boat will be able to remove the snags from the San Joaquin River and from all the navigable fresh-water channels.

Under this view of the case it is not possible to submit a project for a completed system of improvements, at least such a project as could be entertained. Such a project would have to secure the permanency of the banks for many miles of the river and would involve an expense not to be justified under existing circumstances. The day will probably come when such a system will be justifiable and necessary. For the present it is thought that the best policy for the upper part of the river will be to facilitate navigation by a correction of evils as they occur through temporary constructions.

During the first year following the construction of the snag-boat it will be employed almost constantly in clearing out the accumulation of snags all along the river from the head to the mouth, and in cutting down trees that threaten to be snags as soon as the river makes a little more cutting in the bends. This will be the greatest possible improvement to the navigation of the river, and will correct the evils that have thus far been the principal subject of complaint.

The river now shows the benefit of the removal of snags during the past four or five years by a better channel and a freer navigation.

Projects have been prepared for more than a year for Heacock's, the Iron House, and the Ida Shoals in the lower river, below Sacramento. The cost of these improvements is estimated to be $25,000. Here the banks are permanent, and therefore the channel once improved will be permanent. The necessities of the upper river are so much greater, for the present, that the construction of these dams may be deferred until the upper river system of improvement is fairly started by the operations of the snag-boat.

COMMERCE OF THE RIVER.

On the upper river there are three companies engaged in transportation. The transportation is mainly carried on by barges, which are made to carry 600 tons on a draught of 3½ feet of water. The tendency is to larger barges. The down stream is for the most part wheat, and the active season begins with harvest in July and ends when the wheat is exhausted. The quantity of freight depends on the quality of the crop, in which there is a good deal of variation. Last year the quantity of wheat which found exit by the river was about 125,000 tons. The crop is larger this year, and perhaps the amount may be exceeded. The improvement of the river is the only means by which any competition in freight can be maintained. There is a railroad on each side of the river, a few miles distant, both of which are owned by the same company. These roads adjust their freights in some degree in reference to the

river competition. This competition is nearly impossible unless the United States keeps the river in navigable order.

It has not been possible to get accurate statistics of the river business. Last year statements showed a business of about 201,000 tons. The area within reach of the river devoted to wheat increases each year, and therefore it is reasonable to expect a yearly increase of business.

The river is in the custom district of San Francisco. During the past year $5,614,749.64 was collected at this port. The nearest forts and light-houses are on the waters of the bay.

During the coming year the sum of $60,000 can be profitably applied to this river.

Money statement.

July 1, 1879, amount available	$19,176 66	
Amount appropriated by act approved June 14, 1880	45,000 00	
		$64,176 66
July 1, 1880, amount expended during fiscal year		7,764 16
July 1, 1880, amount available		56,412 50
Amount that can be profitably expended in fiscal year ending June 30, 1882.		60,000 00

Abstract of bids for the removal of snags in the Sacramento River, opened July 5, 1879.

No.	Name of bidder.	Price per snag.
1	Seriah D. Stevens	$39 50
2	A. W. Von Schmidt	48 00
3	J. R. Rideout	49 00
4	Albert Foster	55 00

Abstract of bids for the removal and destruction of snags in the Sacramento River, opened June 22, 1880.

No.	Name of bidder.	Price per snag.	Remarks.
1	O. F. Graves	$45 00	Rejected for want of conformity to the requirements of the advertisement.
2	Albert Foster	55 00	

List of contracts made during the year.

No.	Name of contractor.	Date of contract.	Object of contract and price.
1	S. D. Stevens	July 9, 1879	Removal of snags, price $39.50 per snag.
2	Albert Foster	June 22, 1880	Removal and destruction of snags, price $55 per snag.

STATISTICS OF TRANSPORTATION COMPANIES ON THE SACRAMENTO RIVER FOR PERIODS STATED.

1. The Central Pacific Railroad steamers carried during the year 1879 141,369 tons.
2. The Sacramento Wood Company received in freights during the year ending June 30, 1880, the sum of $228,000. The number of tons carried is unknown.
3. No statistics can be obtained from the San Francisco Transportation Company. The amount carried by this company is supposed to be less than that carried by either of the other companies.

SURVEY OF THE UPPER SACRAMENTO RIVER.

A party under the charge of L. J. Le Conte, assistant engineer, was sent, on October 1, 1879, to Red Bluffs, the head of the navigable river, to make a survey from this point to connect with the survey previously made on the lower river. This party kept the field until driven out by the storms of winter. It returned to San Francisco on December 5. During the months following the maps and plans for improvement were prepared in the office.

The survey was carried from Red Bluffs to a point 2 miles below Princeton, where it connected with a survey made in the previous year by the State engineer department. This latter survey extended as far as the mouth of the American, where it connected with the survey of the lower river made in 1878. The State survey included the alignment of the banks, the longitudinal profile of the river, and a number of cross-sections of the river. It also included a number of gaugings of the discharge of the river. It did not include certain special surveys below Princeton, which were thought necessary in the interest of navigation, particularly that at Twenty Mile Bar between Knight's Landing and Colusa. This survey, embracing 8 miles of the river, was made by the party under Mr. Le Conte. Other special surveys were made at points now needing or likely to need special attention in promoting navigation.

These surveys were made in detail, so as to permit the projection of constructions if necessary. Among these may be mentioned Tehama Rapids, Sam Soule's Bar, Munroeville Bar, Deadman's Bar, Call's Bend, Princeton, Twenty Mile Bar, Butte Slough, Wilkins's Slough, Mouth of Feather River, Six Mile Bar, Sacramento, 12 in all. This survey included the alignment of the banks, the longitudinal profile of the low-water stage, the hydrography, and the special characteristics of the river in its different parts.

As a result of all the operations that have been sketched we have now a quite full record of the Sacramento River throughout its navigable extent, which with the subsidiary channels is a length of about 260 miles. This information is sufficient for an intelligent understanding of the requirements of navigation.

THE CHARACTERISTICS OF THE UPPER RIVER.

The term upper river may be applied to that portion lying above Colusa, which is about 100 miles in length. This section of the river may be distinguished from that lying below Colusa by the want of permanency in the banks and channel.

While the river below Colusa is as a whole between sedimentary banks of sufficient power of resistance, the river above Colusa shifts more or less with every flood, and upon its subsidence the navigable channel is found in a number of places to have changed position. In the upper river there are also good banks, but they are not the banks of the river proper. We may imagine them to have been the banks of an ancient river of much larger dimensions than the existing river. The distance between these old banks on the two sides of the river is at the big cut-off, 1½ miles, and at Sam Soule's Bar they approach each other, being two-thirds of a mile apart. Here and there between these limits of width the river touches one of these banks, and whenever this occurs we find the villages and permanent landings from which the products of the country are shipped. The hard banks are generally about the level of high-water or a little lower. Between these permanent banks and lying

about 5 feet below them in height is the alluvial bottom land, generally covered where it has been long undisturbed with a dense growth of sycamores and cottonwoods with some oaks.

In this bottom land the river excavates a new bed at will—elongates itself in tortuous bends and shortens itself by frequent cut-offs. In making these changes of channel it undermines the forests and precipitates them into the river. Some of these trees, particularly the large sycamores, when imbedded in the masses of gravel which the river moves upon its bed, become most formidable dangers to navigation and also most difficult of removal.

Another characteristic distinguishes the upper river, and is in some measure connected with the shifting of its course. This circumstance is the entrance of a number of tributaries carrying gravel of all dimensions. The worst streams come from the west, from the coast range of mountains which borders the river at a distance of a few miles. These streams are generally small, with very considerable falls of 10 feet to the mile or more, and are subject to very severe freshets, which, however, are generally of short duration.

The most formidable of these streams is Stony Creek, which enters the river at Munroeville about 45 miles above Colusa. It drains 600 square miles of mountainous territory and is subject to enormous floods. It carries very large gravel to the river in considerable quantities. The flood discharge has been estimated by the dimensions and fall of its channel to be as much as 80,000 cubic feet per second, which is a good flood rate for the main river. This estimate is probably excessive. The floods are generally of very short duration, lasting only a day or two. The period of maximum discharge is probably much shorter. In summer the stream carries no water on the surface in the lower part of its course. This is the lowest as well as the largest of the gravel-bearing torrents which are tributary to the main river.

It is remarkable that below this point clear to the mouth of the Sacramento, a distance by the channel of 200 miles, no stream directly enters the river from the west. The river for the whole of this distance is bordered on the west by a belt of land lying some feet below the high-water level, which forms a basin for the reception and storage of the drainage water coming from the coast range of mountains. This water finds its escape as the river falls through sloughs, which do not, however, carry any heavy material to the river bed. A similar basin borders the river on the east for many miles above the mouth of the Feather.

Other gravel-bearing streams of less importance than Stony Creek are Reed's Creek, Red Bank Creek, Elder Creek, and Thomas Creek. These all come from the west and are above Stony Creek.

The foot-hills of the Sierra Nevada to the east are further from the river and the slopes of the tributary streams are flatter, so that little or no gravel comes from the east.

There is still another distinguishing characteristic of the upper river. This is its considerable average slope. This is common to rivers in general. Beginning at Colusa, going up-stream, the low river fall averages for the first 20 miles 14 inches per mile; in the next 16 miles the fall is 18 inches per mile; then it increases to 21 inches per mile, and for 40 miles below Red Bluff the fall is on an average 30 inches to the mile. Below Colusa the fall per mile for the first 35 miles averages 5½ inches.

The following table contains the average fall per mile for different parts of the river.

Low-water profile, Sacramento River, California.

Stations.	Distances from Red Bluff.	Elevations above low-water at New York Landing.	Average fall per mile.
	Feet.	*Feet.*	*Feet.*
Red Bluff	0	244.54	
Last Chance	20,000	236.73	2.05
Sacramento Bar	53,000	220.67	2.57
Foot of Saw Mill Rapids	80,000	202.77	3.47
Tehama	93,000	200.82	0.79
Head of Tehama Rapids	95,000	200.56	0.68
Foot of Tehama Rapids	100,000	192.55	8.41
Head of Captain Jane's Rapids	120,000	186.23	1.66
Squaw Hill	153,000	168.48	2.83
Merrill's Wheat Landing	170,000	159.29	2.83
Head of Gazette Chute	185,000	156.66	0.92
Hoodlum Chute	203,000	150.14	1.89
Head of Sam Soule Bar	230,000	139.23	2.12
Foot of Sam Soule Bar	234,000	134.49	7.53
Collay's Ferry	239,000	132.82	1.75
Bidwell's Landing	270,000	127.80	0.84
Chico Landing	298,000	119.18	1.62
Munroeville	326,000	109.50	1.82
Deadman's Bar	356,000	101.86	1.34
Jacinto	384,000	92.66	1.73
Head of Pike's Cut-off	408,000	83.86	1.93
Foot of Pike's Cut-off	418,000	80.22	1.91
Battle City	448,000	73.00	1.26
Princeton	475,000	66.90	1.19
John Bogg's Landing	496,000	61.41	1.37
Calden's Landing	529,000	54.25	1.14
Colusa	595,500	43.20	0.872
Winn's Landing	779,500	27.00	0.177
Knight's Landing	891,500	20.00	0.328
Mouth of Feather River	1,043,500	16.00	0.138
Sacramento City	1,153,000	9.35	0.325
Haycock Shoal	1,204,000	7.40	0.201
Head of Grand Island	1,294,000	4.66	0.160
Rio Vista	1,367,000	1.01	0.263
Collinsville	1,440,000	0.15	0.062
New York Landing, Suisun Bay	1,455,500	0.00	0.050

This fall in the upper river is of course not a uniform fall. It is made up in deep pools, having a low velocity separated by rapids of shoal-water over which the declivity is quite steep.

The principal falls are the Tehama Rapids and Sam Soule's Rapids. In the former there is a fall of 8 feet in 5,000 feet of channel, and at Sam Soule's the fall is 4¾ feet in 4,000 feet. There are a number of other rapids in which the velocity is great and the depth scant.

On the Tehama Rapids there is sufficient water for navigation in spite of the great declivity.

These rapids occur in the portion of the river which carries gravel. Any other material would yield under this velocity.

THE QUANTITY OF WATER IN THE RIVER.

The water supply of the river is a very favorable feature. There is always a sufficient supply when properly controlled to permit navigation.

The low-water discharge at the city of Sacramento below the entrance of all tributaries is 6,000 cubic feet per second. The Feather and American, the only tributaries between Sacramento and Colusa, supply 2,000 cubic feet per second, of which 1,800 come from the Feather. This

gives 4,000 cubic feet per second for the supply in the upper river, supposing none to be lost in passage.

The low-water season is in the autumn. The rains of winter usually keep the river at a good stage until it is re-enforced by the melting of snows in the spring. The freshet from snow is generally past by the 1st of July and the river begins to fall, the lowest stage prevailing from September until the rains begin.

The area of the drainage basin of the river is more than 20,000 square miles. This basin is for the greater part made up of mountains which rise to a considerable height, in some cases in the Sierra Nevada of 11,000 feet, while Mount Shasta, which lies near the headwaters of the river, has an altitude of 14,000 feet. These mountains serve as reservoirs to keep back the moisture of winter for the supply of the river in the many months in which there is no rain. In the higher parts of this drainage basin the precipitation of rain in the 3 or 4 months of winter reaches 90 and more inches. In the plains the fall is less than one-third of this amount. This concentration of a large rainfall within a few months makes it possible under special circumstances for the river to be swollen to enormous dimensions. A warm rain succeeding a heavy fall in the mountains by melting the snow is liable to make a flood which the river bed cannot pretend to carry. This kind of a flood may be called phenomenal from the rareness of its occurrence. As a rule, however, each year for a short time in the winter taxes the capacity of the river and quite frequently this capacity is overtaxed.

It is at this period of high-water that the river runs riot. The tributary streams sometimes enter the river with power sufficient to control the main stream for a time. In some cases they actually form a dam by their entrance, interrupting the stream and sending a current both up and down. They attack the bank of the main river opposite to their own mouths and crumble it with a mighty force. At the same time they leave in the bed of the main river large deposits of gravel which act as a barrier and direct the main stream into a new course and force it to attack the less resisting banks. This temporary control of the main river by a tributary is illustrated in a number of cases. Stony Creek in the upper river does it in flood, and lower down the same thing occurs at the mouth of the American and Feather, and still lower at the mouth of Cache Slough.

If the bed of the upper river were of a yielding character we would probably have a river of permanent alignment, which is the character presented by the lower river; but so long as the bed of the river is paved with gravel, which the current cannot move or move but slowly, and so long as the tributary streams keep up the supply, just so long the alluvial banks will be exposed to attacks which they cannot resist.

The difficulty here resembles in some respects that which has been noticed in other reports on the condition of the lower river. In the latter case the mining detritus works the injury, in the former the heavy gravel. This gravel perhaps might be restrained to some extent and prevented from entering the river in so great quantities, but only at a very considerable cost.

As a consequence the river is exceedingly tortuous, rectifying itself frequently by cut-offs and re-establishing its windings. The old disused channels are wastes of sand and gravel, upon which young willows grow, to be in turn excavated by some future change.

THE NAVIGATION OF THE UPPER RIVER.

The difficulties of navigation are mainly due to the changes of channel. The quantity of water is sufficient, although the depth is often insufficient. The current at the rapids, although very swift, is not an obstacle of the first importance. If the depth is sufficient the boats can overcome the current. A bar, having sufficient water this year, may be a considerable obstacle next year. The best water may be incumbered with snags. Some of these gravel bars are traveling down stream. A bar near the Chico Ferry has been moving at the rate of about 200 feet a year for several years. Other obstructions appear to be sensibly permanent. The two most important rapids on the river, which have already been mentioned, Sam Soule's and Tehama, are of this character, permanent as to locality, although subject to considerable variations of channel.

Where the rapids have insufficient depth, the difficulty can be removed by concentrating the low-water discharge. It may be that this concentration will not be able to excavate the bar; in this case greater depth can be gained by raising the level of the water. An increase of velocity results. Some of these bars will probably have to be deepened by artificial means, if deepened at all. The bars in the part of the river now navigated found to have the least water were Deadman's and Munroeville, both of gravel, and below Stony Creek the depth was 20 inches. This depth holds perhaps for 2 or 3 months of low-river; Sam Soule's Bar has less depth. These bars may all be improved by concentration.

This kind of improvement answers for the season, but next year the bar may have moved down stream or the channel may have taken a new course in its wide bed, renewing the difficulty at a new point. When the difficulty comes, it shows itself at the very height of the river trade, and, if it is to be remedied in time to be of use, the work must be done promptly. This state of affairs forbids the preparation and execution of a project which, when completed, would give a permanent navigation. Such a system is entirely inapplicable to the upper river. The treatment generally will be one of temporary constructions, repeated as often as may be necessary. These works will generally be brush, rising little above low-water, and loaded with gravel. The materials are at hand and are the cheapest that can be used. With a snag-boat belonging to the United States it would perhaps be practicable to keep a construction party on her.

The following table shows the water in 1879 on different bars between Princeton and Tehama rapids, a distance of about 65 miles. Below the Princeton Bar there is everywhere 3 feet or more water:

	Inches.
Princeton, at low-water stage	30
Nigger Jone's, at low-water stage	28
Bee Hive, at low-water stage	28
Reilly's Landing, at low-water stage	30
John Hite's, at low-water stage	26
Glenn's Gardens, at low-water stage	24
Parrott's (upper landing), at low-water stage	30
Deadman's Bar, at low-water stage	21
Munroeville Bar, at low-water stage	20
Below Chico Ferry, at low-water stage	30
Flora Bend (below Bidwell's), at low-water stage	24
California Island (below Bidwell's), at low-water stage	30
Sam Soule Bar (lower end)	14
Sam Soule Bar (middle bar)	24
Wilson's Lower Bar	20
Wilson's Upper Bar	24

	Inches.
Mark Reazer's Lower Bar	30
Mark Reazer's Middle Bar	33
Hoodlum Chute	30
Eastman's Landing	30
Below Gazelle Chute	30
Merrill's Wheat Landing	18
Moore's Cut-off	20
Mouth Deer Creek	30
1° above Deer Creek	30
Captain Jane's Bar	18
Thome's Creek	30
Cherke's Chute	30

So far as a system is possible, it ought to be directed to improving bars with less than 30 inches to give at least that depth.

The trade of the upper river is principally the towing of wheat barges which, fully loaded, carry 500 or 600 tons, and draw 4 or 5 feet of water. The barge is towed astern of a light-draught steamer at the end of a long hawser. Below Colusa there is plenty of water, so that the barge usually finishes its load at this point.

The wheat coming from the upper landings is loaded with reference to the depth of water on the bars, so that an improvement in depth at once cheapens transportation. On the other hand, it may be said that the very low-water seldom holds more than three months. These are, however, the three months just succeeding the harvest.

A worst enemy to navigation is the abundance of snags. The causes that keep up the supply have been mentioned. For a number of years back the worst snags have been removed under contract. This is but a palliation of the evil.

The thorough treatment and clearance of the river requires the United States to own a properly equipped boat. Keeping the boat on the river during the low-water season, with a party of workmen aboard, it will be possible to remedy the shoalness of water on the bars, as soon as it shows itself in the summer, by the construction of cheap brush-dams. In this way it is thought that 3 feet of water can be maintained between Sam Soule's Bar and Colusa. This depth will allow the large barges to carry 500 tons of wheat, which is a good freight. Above this point the river can be made to carry a depth of 2 feet at the lowest stage by a reasonable expenditure.

K K 4.

IMPROVEMENT OF PETALUMA CREEK, CALIFORNIA.

The original estimate for this improvement was \$25,868.40. The act of June 14, 1880, appropriates \$8,000. It is proposed to devote this to straightening the creek by cutting off the two bends nearest to the town of Petaluma. This work will require by the estimate 22,420 cubic yards, and it is supposed that the funds now available will be sufficient for the purpose.

The funds asked for the year ending June 30, 1882, will be applied to dredging the channel to a depth of 3 feet at low-water. The estimate for the completion of this improvement is now placed at \$20,000 instead of \$17,868.40, as originally estimated. The reason for this change is that the work cannot be done economically when only a portion can be contracted at one time.

The riparian owners along the creek have, it is believed, agreed in

writing to release to the United States the land necessary for making the cut-offs. It is also supposed that no objection will be made by owners of land to the placing of the excavated material on the land.

This work is in the collection district of San Francisco, at which port the amount of duties collected in the last fiscal year was $5,614,749.64. The nearest forts are those in the harbor of San Francisco.

Petaluma is the natural outlet of a considerable area of agricultural country. The commerce of the port is carried on by a steamboat which makes daily trips to San Francisco, and by a regular fleet of about thirty schooners, averaging 50 tons each. During a portion of the year the number of schooners is increased to fifty.

A detailed statement of the trade of the creek, from December 1, 1878, to November 30, 1879, accompanies a report on this improvement published as Senate Ex. Doc. No. 68, Forty-sixth Congress, second session.

Money statement.

Amount appropriated by act approved June 14, 1880	$8,000 00
July 1, 1880, amount available	8,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	20,000 00

EXAMINATION OF PETALUMA CREEK, CALIFORNIA.

SAN FRANCISCO, CAL., *December* 2, 1879.

GENERAL: Agreeably to the instructions of the department, I made in September an examination of Petaluma Creek, of a character sufficient to enable instructions to be given for a survey.

The survey has since been made, and I now have the honor to submit a report upon the improvement of this channel.

Petaluma Creek is one of several tidal channels which make from the great bay of San Francisco, winding a tortuous course through the belt of marsh which borders the bay and extending a number of miles through the interior to a terminus where the marsh adjoins the upland. Napa and Sonoma Creeks are other examples. These streams are all navigable for small vessels, and afford an easy communication for limited districts with the great central market of San Francisco.

During the rainy season these channels receive and carry off the fresh-water drainage of the country which adjoins, but at no time is this drainage sufficient in quantity or permanent enough of itself to supply or maintain a navigable stream. During the greater part of the year the fresh-water drainage is quite insignificant, and for only two or three months in the winter is it at all considerable. So far as benefit is concerned it may be neglected. The injury, however, cannot be neglected.

The earthy matter which the back drainage brings to the channel is a positive injury, which cannot be overlooked, nor can it be prevented.

The wash from the land has already filled the channel above the town of Petaluma, and tends progressively to reduce the section of the channel throughout the upper portion.

It is, then, more or less of a misnomer to class this channel as a creek. It is really a tidal estuary—trumpet-shaped—the wider end at the mouth, in the bay of San Pablo, dwindling to a narrow channel at its upper extremity, where is the flourishing town of Petaluma.

The channel is about 15 miles in length; at the mouth the high-water width is about a mile. At Petaluma the width is reduced to 60 feet.

The lower half of the channel affords good navigation as far as Donahue, which is the terminus of the North Pacific Railroad, and about half-way between the bay and Petaluma. Nothing is required to be done here at present. Above Donahue the navigation is considered to be very fair, for 3 or 4 miles, although in one place it would be a convenience to have a greater depth. The great difficulty is found in the stretch of 4½ miles just below Petaluma. This stretch is the portion that has been surveyed, and it is to this portion that the estimate to follow refers.

The whole estuary is undergoing degradation. At some time in the past the tide ebbed and flowed freely over the whole belt of marsh through which the estuary now winds its course. The wash from the upland, aided by the deposit of the flood tide, has redeemed the marsh from all but a partial control of the tide. The territory of tidal supremacy has been reduced year by year and the dimensions of the channels of ebb and flow have varied always from greater to less.

If it were possible to pick up this estuary and replace it reversed, with its wide mouth at Petaluma, or above, instead of where it is, 15 miles below, we would thereby secure a reservoir at the head, which, emptying and filling twice a day, would serve to maintain a good channel below. The conditions of permanency are, however, wanting. If the channel is to be kept navigable it must be by dredging.

The difficulties in this stretch of channel just below Petaluma are twofold. First, the channel is in two places so crooked that it is with difficulty that vessels can pass along. There is a third point where the difficulty is not so great. If the channel were straightened at these points it would be shortened 1 mile, so that the length of this stretch would be 3½ instead of 4½ miles.

This exceeding tortuousness is characteristic of this channel. Two bends have already been cut off, to the great improvement of the navigation. This was done some years ago by parties engaged in transportation on the creek.

The second difficulty is want of depth. At low-water the channel for about 2 miles below Petaluma is dry, and vessels can be moved only when the tide is up. If a depth of 3 feet were made at low-water there would be, by reason of the tide, as much as 7 feet at every high-water, and in spring tides as much as 10 or 11 feet.

The commerce of the creek, and particularly of the upper portion, is, then, necessarily done by vessels of light draught and tonnage, and then only when the tide is up. A considerable trade is, however, maintained with San Francisco, as will be seen by the statistics which accompany this report.

There is a daily steamer to and fro between San Francisco and Petaluma. This steamer makes her landing at the lower end of the stretch which has been described. The passengers are sent to Petaluma by land, and freight is transferred to a small steamer which goes by the tide to the town. In addition to this steamer there is quite a fleet of small sailing-vessels engaged in this commerce.

With the depth of 3 feet at low-tide, the San Francisco steamer could make a landing at the town and save the transshipment of freight. Even then, however, owing to the narrowness of the channel, the navigation would hardly be the best, although a great improvement upon the present circumstances.

Petaluma is 40 miles from San Francisco. It is a flourishing town of 4,000 or 5,000 inhabitants. The country adjacent is fertile and well settled, unusually so for California.

The lands are held in small tracts, and there is an air of comfort and

thrift which is wanting in many agricultural districts of the State. This section of the country is always favored with sufficient rain for purposes of cultivation, which is not by any means the case with all other parts of the State.

As has already been stated, Petaluma is at the head of navigation. It is the natural outlet of a considerable area of agricultural country watered by the Russian River.

The San Francisco and North Pacific Railroad is built to Cloverdale, about 50 miles above Petaluma. This road has its terminus at Donahue, on the creek, about 8 miles below Petaluma. Much of the trade of the interior which naturally belongs to Petaluma, is, owing to the existence of the railroad, carried by it to Donahue and thence to San Francisco. Nevertheless, the town of Petaluma is prosperous and does a large trade in fruit, dairy products, and wheat. These productions are hauled by wagon to Petaluma from the country within, in the radius of a day's journey, in order to take advantage of the cheaper water carriage.

A considerable number of people would, therefore, be benefited by an improvement making the navigation more convenient and the freights cheaper.

Petaluma is in the collection district of San Francisco, at which port there was collected for customs in the last fiscal year, the sum of $6,147,840.24.

The nearest light-houses are those on Mare Island and on the Brothers in the bay of San Pablo.

The nearest forts are those in the vicinity of San Francisco.

ESTIMATE.

The quantity of excavation necessary for those cut-offs, to straighten the channel and shorten it 5,582 feet, making the cut 50 feet wide at low-water and 3 feet deep, is, in cubic yards	43,096
The quantity of excavation to give 3 feet of water in the channel is, in cubic yards	43,132
Total cubic yards	86,228
Which, at 30 cents, amounts to	$25,868 40

This amount ought to be available in one sum.

A statement of the trade of Petaluma for the year ending November 30, 1879, is inclosed.

Very respectfully, your obedient servant,

G. H. MENDELL,
Lieutenant-Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The undersigned, your committee, herewith present to your honorable body the accompanying report of the commerce and navigation of the Upper Petaluma Creek for the year commencing December 1, 1878, to November 30, 1879.

The steamer Pilot makes daily trips to and from San Francisco, and, in addition to her freight, has carried 13,046 passengers.

Thirty schooners, of an average tonnage of 50 tons, are engaged regularly in the trade, and about 20 other transient schooners a portion of the year.

We have not included in our estimate shipments made over the railroad by way of Donahue, many shippers preferring that route on account of the delay and uncertainty of time by the creek.

			Tons.
Wheat	centals	379,090	18,954
Barley	do	61,790	2,239
Oats	do	12,200	610

			Tons.
Potatoes	centals..	189,100	9,450
Bran and middlings	do....	5,000	250
Corn	do....	4,000	200
Fruit, 58,139 boxes	pounds..	2,906,950	1,453
Butter, 16,055 boxes	do....	1,605,500	802
Cheeses, 4,610	do....	138,300	69
Wool	do....	164,100	82
Eggs, 2,020 boxes	dozen..	60,600	
Wood	cords..	1,520	
Tan-bark	do....	200	
Lime	barrels..	750	
Brick		250,000	
Lumber	feet..	1,140,000	
Paving-blocks		1,458,500	
Head of live stock		48,256	
Hay			9,625
Coal			1,720
Other general merchandise			26,020
Passengers by steamer Pilot		13,046	

Respectfully, yours,

J. G. WICKERSHAM.
A. P. WHITNEY.
JOHN A. MCNEAR.

The Hon. BOARD OF TRUSTEES
Of the City of Petaluma.

APPENDIX L L.

IMPROVEMENT OF THE HARBOR AT SAN DIEGO—IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

REPORT OF LIEUT. COL. C. SEAFORTH STEWART, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 6, 1880.

SIR: I have the honor to transmit herewith annual reports for the fiscal year ending June 30, 1880, of the river and harbor works in my charge.

Very respectfully, your obedient servant,

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

L L 1.

IMPROVEMENT OF THE HARBOR AT SAN DIEGO, CALIFORNIA.

During the past winter, owing to a heavy rain fall of over 4 inches in three days, the San Diego River rose high enough to overflow its banks in two or three places, and with its waters reach for a short time the stone facing of the levee which borders the artificial channel. The flood did not last long and caused no injury to the works. The surface water from the top of the embankment in flowing down the slopes gullied them at many points. The necessary repairs have been made, and according to the last report received the works are in good condition.

The balance on hand from the last appropriation will probably be sufficient for making repairs for several years to come.

FINANCIAL STATEMENT.

Appropriated by act approved March 3, 1875	$80,000
Expended to June 30, 1879	80,000
Appropriated by act approved March 3, 1879	1,000
Expended to June 30, 1880	75
Available July 1, 1880	925

This improvement is situated in the collection district of San Diego. That town is the nearest port of entry. Point Loma light is the nearest light-house. The work begun at Ballast Point is the nearest fort.

The amount of revenue collected at San Diego during the fiscal year is given as $5,958.94.

Money statement.

July 1, 1879, amount available	$1,000 00
July 1, 1880, amount expended during fiscal year	75 00
July 1, 1880, amount available	925 00

Amount that can be profitably expended in fiscal year ending June 30, 1882 depends on damages to works that may take place during the year.

L L 2.

IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

The project for the expenditure of the $20,000 appropriated by act approved August 14, 1876, for this river, adopted in 1877, contemplated the removal of portions of sharp points at bends in the narrows below Stockton Channel to facilitate the passage of vessels, and also embraced the dredging of certain shoals so as to give a depth of at least 6 feet, at low stage of water, in the channel.

This work was finished in 1878 at an expenditure of $19,370.09.

It was proposed with the small unexpended balance to have, during the low river of the past year, a resurvey of that part made by the assistant, who had been formerly in local charge of operations. At the proper season he was not, however, available and the river of late has risen too high for the purpose.

FINANCIAL STATEMENT.

Amount originally appropriated	$20,000 00
Expended to July 1, 1879	19,370 09
Expended during year ending June 30, 1880	18 14
Amount available July 1, 1880	611 77

This sum can probably be profitably expended on a survey.

This portion of the river is thought to be in the collection district of San Francisco. The nearest light-house is at Mare Island. The forts in San Francisco harbor are the nearest. San Francisco is the nearest port of entry.

During the past fiscal year, it is stated, the amount of revenue collected in San Francisco is $5,614,749.64.

Stockton being the outlet for the San Joaquin basin a large amount of navigation would be benefited by the improvement of the river.

Money statement.

July 1, 1879, amount available	$629 91
July 1, 1880, amount expended during fiscal year	18 14
July 1, 1880, amount available	611 77

L L 3.

EXAMINATION OF TRINIDAD HARBOR, CALIFORNIA.

SAN FRANCISCO, CAL., *March* 27, 1880.

SIR: By letter dated Washington, D. C., April 25, 1879, the examination or survey of Trinidad Harbor, California, provided for by act of Congress approved March 3, 1879, was placed in my charge.

No report on the subject has been made hitherto, as this was one of the harbors which the Board of Engineers for the Pacific Coast had under consideration in making selection of a site for a breakwater and harbor of refuge on the coast between San Francisco and the Straits of Fuca. Trinidad not having been chosen by the Board, I now submit the following report:

An examination of this roadstead was made in July last. From soundings and from specimens of the bottom obtained then it was found no change in the depth of water or in the character of the material of the bed appeared to have taken place since the United States coast survey made in 1872, the results of which were published in 1874 in a chart of this harbor. It was thought, therefore, a new survey was not needed.

Trinidad is in latitude 41° 03′ N., longitude 124° 08′ W., a few miles south of the midway point between San Francisco and the mouth of the Columbia River. It is in a bight of the coast, sheltered on the west from northwest winds by a bold, rocky peninsula, about 380 feet high, called Trinidad Head. From this point the bluffs extend by the north to the east and south. The cove thus formed is about 1¼ statute miles long, measured from the head to the 3-fathom curve of the bottom on an east and west line, with a greatest width from this line to the same curve of nearly ⅝ of a mile. The depth of water within these limits varies from 3 to 7¾ fathoms. The best anchorage, though somewhat limited, is found in the western portion.

Cape Mendocino lies to the south, about 43 statute miles distant. The coast-line between the cape and Trinidad Head protects the roadstead to a great extent from winds and seas from the east to the south. It is exposed to a heavy swell from the south and west in heavy southerly weather, and sometimes when there is but little wind close inshore. If this were cut off, the anchorage would be quite secure at all times. As it now is, it forms a good shelter against the summer northwest winds.

The approaches are free from hidden dangers. The rocks to the westward of the Head are close inshore and can be easily avoided. There are but few sunken rocks in the harbor. The head is a good landmark. The holding ground is equal to that at most of the anchorages on the coast. Offshore soundings have been taken, and these would aid in judging of one's position in approaching Trinidad in thick weather. These are all favorable points, and those interested in this place are desirous to have it made the site of an artificial harbor, by the construction of a breakwater from the Head to Pilot Rock. The expense of such a work would be altogether out of proportion to the amount of commerce to be benefited, if that of Trinidad alone was to be considered.

The country in this vicinity is well wooded, and from the redwood timber much lumber is manufactured and exported. This is the principal business of the place, and is carried on by the Trinidad Mill Company, which owns two saw mills, one only being at work at present. The village is small, its residents being chiefly those employed by the above company.

Statistics of the trade with Trinidad will be given further on.

Some 20 miles to the southward of this roadstead is the entrance to Humboldt Bay, which is a point of much commercial importance. During the year 1878 there were 583 vessels, measuring 134,371 tons, passing to and from Humboldt Bay and San Francisco, and 2,397, measuring 208,792 tons, between that city and ports south of Cape Mendocino. The yearly averages of the number of vessels engaged in trade on this part of the California coast do not probably differ much from those just given. These vessels are chiefly small coasters and steamers. The

sailing vessels are not always well found, do not carry spare sails, go short-handed and with scant supplies. If there were a secure harbor at Trinidad, such vessels, when driven to the northward of Cape Mendocino in southerly gales in winter, would endeavor to make it; and in such weather vessels bound to Humboldt, unable to cross the bar, might, instead of knocking about at sea, run into Trinidad and wait until a favorable change took place. Probably few other vessels would avail themselves of the harbor.

On the accompanying tracing is shown a line for a breakwater running from the south point of Trinidad Head to Pilot Rock, a distance of about 900 yards. The general direction of the work is a little to the west of south, and would cut off the seas which it is stated come in from the west or to the southward of west in the winter gales. The depth of water in which it is placed varies from 5 to 8¾ fathoms. In 10 fathoms of water would, perhaps, be preferable, as seas on this coast are said to break in very deep water. Still it is not likely that it would often happen that a vessel would have to pass through breakers to get under shelter of the work as located. The area protected from southwest seas exterior to the 3-fathom curve of the bottom is about 260 acres; against a westerly sea double this area would be sheltered. The entrance to the southward is about 1¼ miles in width, with a greatest depth of 9¼ fathoms. The average rise of tide is 5 feet; of spring tides 7 feet.

The body of the work would be built of rock taken from the Head. This is composed of a metamorphic sandstone not homogeneous, and which probably cannot be got out in large blocks if it quarries like similar stone elsewhere. The mass of rubble thrown in to form the heart of the work would therefore have to be faced, it is supposed, with blocks of artificial stone or concrete of sufficient size to resist the action of the waves.

The inclination given to the outer slope, from the bottom to 25 feet below lowest water of spring tides, where the sea is supposed to have little, if any, effect in moving the material, is 4 on 5; thence to the top taken at 10 feet above high-water, the inclination is 1 on 3. Above low-water the mound is to be of blocks weighing 25 tons, and more if necessary; from low water to 25 feet below, the outer coatings are supposed to be of stones weighing from 2 to 10 tons; thence to the bottom; the exterior to be covered with rubble of from ¼ of a ton in weight to 2 tons.

The general disposition of the material is indicated in the section on the tracing already referred to.

In estimating the cost of construction the quantities are computed without making any allowance for voids, and the rates given are for the material as put in place in the work.

ESTIMATES.

25-ton blocks, concrete, 172,206 cubic yards, at $12	$2,066,472 00
10-ton blocks, concrete, 90,000 cubic yards, at $10	900,000 00
2 to 6 ton stones, 201,000 cubic yards, at $5	1,005,000 00
Rubble, 672,442 cubic yards, at $1.25	840,552 50
	4,812,024 50
Contingencies 10 per cent	481,202 50
Total	5,293,227 00

The Head, from which stone would be obtained for the work, is, it is understood the property of the United States.

If an artificial harbor is made here it will become necessary to provide fortifications for its defense.

The Messrs. F. P. & J. A. Hooper have furnished the following tabular statement for the port of Trinidad, showing the arrivals and departures of vessels, the value of goods and merchandise imported, and the quantity and value of lumber exported by the Trinidad Mill Company from 1875 to 1879, inclusive:

Year.	Number of arrivals.	Tonnage.	Value of goods.	Number of departures.	Tonnage.	Feet of lumber.	Value of lumber.
1875	52	9,906	$66,743 92	52	9,906	10,265,985	$223,917 35
1876	46	8,295	66,677 95	46	8,295	8,411,593	171,638 56
1877	30	5,674	27,073 70	30	5,674	5,726,491	92,396 62
1878	29	3,914	37,719 79	29	3,914	5,120,784	75,944 04
1879	25	4,137	26,090 55	25	4,137	4,645,960	67,580 70

The company ran two mills in 1875 and 1876; since then but one, owing to stagnation in the lumber trade. They estimate the value of goods shipped to Trinidad by others than the company at about 30 per cent. additional. The shipments from Trinidad by other persons are unimportant.

This port is in the collection district of San Francisco, which city is the nearest port of entry. The amount of revenue collected at San Francisco for the year ending June 30, 1879, was $6,147,840.24.

There is a light-house at Trinidad.

The nearest fortifications are those of the harbor at San Francisco.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant-Colonel of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

APPENDIX M M.

IMPROVEMENT OF RIVERS AND HARBORS IN OREGON AND IN WASHINGTON TERRITORY—IMPROVEMENT OF LOWER CLEARWATER RIVER, IDAHO—CONSTRUCTION OF CASCADES CANAL, COLUMBIA RIVER.

REPORT OF MAJOR GEORGE L. GILLESPIE, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., July 10, 1880.

GENERAL: I have the honor to submit herewith my annual report upon works of river and harbor improvements and of surveys and examinations under my charge for the fiscal year ending June 30, 1880.

I am, general, very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

M M 1.

IMPROVEMENT OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS FROM PORTLAND, OREGON, TO THE SEA.

The plans adopted by the Board of Engineers for the Pacific coast, April 9, 1877, for the improvement of the bars in the Lower Willamette and Columbia rivers, provided for the construction of dikes and dams formed of brush and stone. These plans were reconsidered by the Board, in session at Portland, Oreg., August 6 and 7, 1879, and they were so far modified as to substitute constructions made of piles, fascines, and stone for those previously recommended.

The new plans received the approval of the Chief of Engineers August 22, 1879. As the results to be obtained by the dam at the head of Willamette Slough bore directly upon the character and extent of the improvement designed to deepen the channel across the bar at Saint Helens, Columbia River, at the foot of the slough, it was deemed best that the dam should be built first in connection with the dike at Swan Island Bar, Willamette, where the shoalest water prevailed.

Sealed proposals for doing the work by contract were invited by public advertisement dated September 4, and opened 11 a. m., Thursday, September 25, 1879. The lowest bid, which was presented by an irresponsible bidder, was rejected, and the contract was, with the approval

of the department, awarded to Messrs. Paquet and Smith, of Portland, Oreg., the next lowest bidders. On the day of the opening of the proposals I was unofficially notified by the president of a prominent transportation company that if the improvement contemplated at Swan Island were commenced his company would enjoin the work as tending to interfere with the free and convenient use of certain wharves they were soon to build in front of property lately acquired by them for purposes of construction and repair of steamers. The matter was referred to the department by letter of October 2, 1879, and on the 16th of the same month I was authorized to defer the work temporarily. To compensate for the work at Swan Island Bar, which was thus deferred, the contractors were allowed, without increase to the prices contained in their bid for the Swan Island work, to make the dike closing Coon Island Slough and to revet Coon Island, both on the left bank of the Willamette, at its mouth. Under this contract the dam in the Willamette Slough was commenced October 14, and was practically completed November 20, 1879, though riprap was added to the exposed side, from time to time, until the contract was closed on April 10 The dike revetment at the mouth of the river was commenced November 4, 1879, and continued, with more or less interruption from high-water in the Willamette and backwater from the Columbia River, until April 1, when all operations were suspended on account of the exhaustion of the appropriation.

The following is an abstract of the improvement completed and placed in what is believed to be a thoroughly protected state:

DAM ACROSS WILLAMETTE SLOUGH.

Consists of pile, fascine, and stone dam across the Willamette Slough, ¼ of a mile below the head, with an open channel through the center, 100 feet wide by 13 feet deep at low-water, revetted with timber cribs 50 feet by 25 feet.

	Feet.
Width of dam from center to center of piling	10
Height of dam	16
Length (exclusive of cribs)	631½
Height above low-water (mean)	2
Length of shore protection at ends of dam	310

This improvement was thoroughly completed.

DIKE ACROSS COON ISLAND.

This dike is of the same general character as the above, and commencing near the outer shore line of Sauvie's Island runs in the direction of Coon Island. The inner end of the piling, for some distance south along the shore of Sauvie's Island, is protected by fascines and brush picketed to the ground and ballasted with heavy stone.

	Feet.
Length of dike (completed)	597
Length of dike yet to be built	980
Shore protection at Sauvie's Island, single row of piles, fascines, and stone	86
Shore protection, fascines, and stone	347

REVETMENT OF COON ISLAND BANK.

This revetment completely encircles the island from Coon Island Slough along the eastern shore to the Columbia River. It is formed of close piling in front strongly united at top with double waling timbers securely

bolted and spiked to the piles; connected with a rear row of piles, 12 feet apart, by cross timbers and iron rods, and the intervening space filled with fascines, brush, and stone.

	Feet.
Length of revetment (completed)	1,386
Height of top above mean water level	4

The special details of these constructions are given in the report of Assistant Engineer R. A. Habersham, herewith transmitted, to whom I am much indebted for faithful and zealous service throughout the year.

RESULTS OF THE IMPROVEMENTS.

Too short a time has elapsed since the improvements were built to enable me to give an accurate statement of the gains which have been made in the depths over the adjacent bars, but soundings made just before the beginning of the work, and again in February last, show a gain of 2 feet on Post-Office Bar, Willamette River, just below the Willamette Slough, and of 3½ feet at the mouth of the Willamette, besides an increase of width in the channel at the mouth of the Willamette. Extensive shoalings have been remarked in the slough below the dam, in Coon Island Slough behind the dike, and also close to the south end of the island where formerly very deep water was found. At or near low stage the main current of the Willamette will follow closely the east shore of Sauvie's Island, continue beyond along the line of the dike and the revetment of the island, and will keep, it is believed, the channel completely scoured out so as to prevent any future troubles to sea-going vessels at the entrance. This result can only be reached in its perfection by completing the dike to a junction with the revetment at Coon Island, a distance previously given of 980 feet.

The dredger was overhauled early in the month of August, and was set to work September 2, dredging at the mouth of the Williamette, where a survey had indicated the presence of a shoal 300 feet wide with an average depth of less than 16 feet water at low-water. By the 24th a channel was opened through the shoal 105 feet with 18 feet of water, after the removal of 5,960 cubic yards of material. The dredger was then transferred to Saint Helen's Bar.

At this point the channel, which was opened in 1876 and which has been maintained ever since, runs obliquely across the bar, on the shortest line between the deep water curves on both sides, and is very badly located for a favorable action upon it by the river currents.

An attempt was made to scrape the channel by using a large and powerful scraper lately made to replace a light one which had formerly been used on the dredge and which had lately been transferred to the snag-boat in use on the Upper Willamette. The attempt was not successful, as there was not sufficient current through the channel to convey away the material displaced by the scraper. The scraper was laid aside for use at points lower down and the dredger again brought into service. The inner bank on the upper side and the outer bank on the lower side were cut away to convenient distances and a deep cut with 18 to 19 feet of water made along the new axis; after which the range beacons on shore and the buoys were changed to conform to the new channel. This work was completed on the 8th of November after the removal of 10,980 cubic yards of material. From that date till the 3d of December the dredger was used at Swan Island, and removed during that period 3,855 cubic yards of material. The river rose suddenly to 6 feet above low-water, and the dredger was drawn off and laid up for the

winter. The total amount of material removed during the season was 20,795 cubic yards in 41 working days. As the river is narrow and the channel-way quite restricted for deep-draught vessels, a great deal of time was lost by the dredger in drawing out of the channel to give room for steamers and vessels to pass, thereby considerably reducing the effective and economical results obtained during the time the operations were in progress.

To enable large steamers and vessels which desire to put to sea at early dawn to readily distinguish the channel across Swan Island Bar, the light-house department has lately driven a pile beacon, with targets, at the inner black buoy a little inshore. It is similar in construction to the one driven last year on Three Tree Island and has proven a great benefit to commerce.

A little shoaling has occurred during the year at what is known as the Hog's Back, or the point at which the main channel of the Columbia River forces its way through the widely extended sand shoals on the immediate approach to Tongue Point from the east. The scraper was taken there on December 19 and used very efficiently during three days, but this operation was soon suspended to escape an ice blockade which was forming above and which threatened to prevent the return of the plant to Portland. The work which was done during this limited period increased the depth over the shoal 18 or more inches and was most satisfactory to all shipping interests.

After the 22d of December the Columbia River, above the mouth of the Willamette, was closed by ice, but little ice formed in the Willamette, and the Portland and Astoria River boats and the ocean steamers made regular trips from Portland to the sea; the former, as a matter of precaution, passing for several days through the Willamette Slough to avoid detention by ice at Willow Bar, 6 miles below the mouth of the Willamette.

SURVEYS DURING THE YEAR.

Frequent surveys have been made of all the shoal bars in both rivers from Portland to Saint Helen's to indicate the changes in the channel and to see that the buoys accurately mark the direction of the deepest water. This careful watchfulness of the bars has been eminently satisfactory in its results, as but few vessels have been detained during the year at these obstructions, and only those which by bad pilotage were taken out of the deep-water channel.

MOUTH OF THE COLUMBIA RIVER.

A survey of the bar at the mouth of this river was made August–October, 1879, under the personal direction of G. M. Jessen, assistant engineer, in continuance of the survey of the previous year.

The changes which have occurred in the channels, and my views relative to the opening of a new channel, together with plans and estimates for the construction of a rubble training-wall for directing the ebb currents in a direction favorable for checking deposits of sand in the lower harbor inside the bar, are all embodied in my report to the department dated December 17, 1879, and printed in Senate Ex. Doc. No. 34, Forty-sixth Congress, second session. I can only say that it is the only one which my present knowledge of the locality and its exposure will permit me to present for the consideration of the department.

POINT ADAMS AND CLATSOP SPIT, AND SAND ISLAND.

The annual survey of the shore line at these points was made by direction of the department from the appropriation for "improving the mouth of the Columbia River," and the details will be found in the report under that head.

The appropriations made for the improvement from act of June 23, 1866, to act of March 3, 1879, both inclusive, have been, in the aggregate ..	$315,365 00
By act of June 14, 1880, $45,000 were appropriated, making the total appropriation to date	360,000 00
Of this amount there have been expended to date	315,004 68

It is expected that the amount available at this date will be applied in closing Coon Island Slough by extending the unfinished dike 980 feet to connect with the improvement on Coon Island, and in dredging bars in the Columbia River where it shall be discovered that there is not sufficient water for sea-going vessels.

Of the amount necessary to complete the existing project $100,000 can be profitably expended during the next fiscal year in building the dike projected at Swan Island Bar, and dredging and scraping bars in the Lower Columbia. In addition to this I would recommend an appropriation of $50,000 for the purchase of a first-class dredge of improved pattern, with scows complete, to replace the present one in use, which is now nearly worthless, and should be discarded.

These rivers are in the collection district of Oregon, with a port of entry at Astoria, 12 miles from the mouth of the Columbia and of the Willamette, with a port of entry at Portland, 12 miles above the mouth of the Willamette River. There is a light-house and a work of defense on either shore at the entrance to the Columbia River. The light-house south of the entrance to the south channel has a 12-inch steam fog-whistle giving a blast of 7 seconds, interval of 14 seconds, then a blast of 4 seconds, followed by an interval of 35 seconds. Three miles south of the bar, at the entrance by the south channel, there is also an automatic buoy in 17 fathoms. Before the close of the fiscal year the Light-House Department will have established a light-house and fog-signal station on Tillamook Rock, 20 miles south of the Columbia River Bar. The light will be of the first order, "scintillating," and the fog-signal will be a steam siren of the first class. This improvement will be of great benefit to the shipping making the Columbia River entrance.

ASTORIA STATISTICS.

I am under obligation to the Hon. W. D. Hare, collector of customs at Astoria, for the following commercial statistics relative to the port of Astoria from July 1, 1879, to June 26, 1880:

Value of exports	$1,973,221 00
Value of imports	28,276 00
Revenue collected	29,126 00

Coastwise vessels entered, 202; tonnage	331,573
Coastwise vessels cleared, 193; tonnage	325,273
Foreign vessels entered from foreign ports, 25; tonnage	21,890
Foreign vessels cleared for foreign ports, 43; tonnage	45,070
American vessels entered from foreign ports, 2; tonnage	2,454
American vessels cleared for foreign ports, 13; tonnage	10,276

PORTLAND STATISTICS.

I am under obligation to the Hon. John Kelly, collector of customs at Portland, Oreg., for the following information referring to Portland for the eleven months ending May 31, 1880:

Amount of revenue collected	$97,441 82
Value of imports from foreign countries	264,633 70
Value of exports to foreign countries	4,081,188 40

Number of foreign vessels entered from foreign countries, 58; tonnage	54,366
Entered coastwise, 13; tonnage	11,458
Number of American vessels entered from foreign countries, 6; tonnage	3,456
Number of foreign vessels cleared to foreign countries, 73; tonnage	66,856
Number of American vessels cleared to foreign countries, 30; tonnage	20,912
Number of coastwise entrances, 114; tonnage	162,909
Number of coastwise clearances, 87; tonnage	149,425

The following statistics referring to the "Sound" have been furnished me through the courtesy of Hon. H. A. Webster, collector of customs, Port Townsend, Wash.:

DISTRICT OF PUGET SOUND—STATISTICS FROM JUNE 30, 1879, TO MAY 31, 1880.

Amount of revenue collected	$16,726 00
Value of imports	17,500 00
Value of exports	392,000 00

Number of foreign vessels entered, 92; tonnage	30,700
Number of foreign vessels cleared, 93; tonnage	31,600
Number of American vessels entered, 257; tonnage	167,100
Number of American vessels cleared, 231; tonnage	140,300

During the year about 100,000 tons of coal and 100,000,000 feet lumber left Puget Sound coastwise in vessels under enrollment and license, which are not required to enter and clear. The foreign trade has fallen off during the past year on account of the South American war—Chili and Peru, in time of peace, being heavy buyers of Puget Sound lumber.

The commerce of the Columbia River is rapidly increasing in importance every year, and liberal appropriations should be made for improvements which have for their object the removal of obstructions to an uninterrupted navigation of the Columbia and Willamette Rivers by seagoing vessels and steamers of the largest class at lowest stage as far as Portland. The agricultural richness of Oregon and Washington Territory, east of the Cascades, is shown in the rapid rise and increase of the material wealth of the city of Portland, which is the grand entrepot for all the products of the Columbia and its several tributaries.

Abstracts of proposals and contracts, a statement of funds and charts showing the improvements made and the varying stages of the water in both rivers during the year are transmitted herewith.

Money statement.

July 1, 1879, amount available	$71,707 00	
Amount appropriated by act approved June 14, 1880	45,000 00	
		$116,707 00
July 1, 1880, amount expended during fiscal year		71,711 68
July 1, 1880, amount available		44,995 32
Amount (estimated) required for completion of existing project		178,974 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		150,000 00

Abstract of proposals for furnishing the United States with a tug-boat, when required, as tender to the United States dredge during the year 1879, opened by Maj. G. L. Gillespie, Corps of Engineers, July 10, 1879.

No.	Names and residences of bidders.	Names of tug-boats.	Horse-power.	Draught of water.	Rate per month.	Remarks.
			No.	*Feet.*		
1	C. Leinenweber, Astoria, Oreg.	Katata	25	4½	$447 50	Not acceptable.
2	Charles R. Wilson, Portland, Oreg.	Portland	25	6	515 00	Do.
3	Robert Watson, Astoria, Oreg.	Rip Van Winkle	40	6	550 00	Excellect boat, and capable of rendering proper service to the dredge.
4	J. G. Megler & Co., Brookfield, Wash.	Edith	55	6½	575 00	Not acceptable.

Abstract of proposals for the construction of a pile-dike in the Willamette River, near Swan Island, Oregon, opened by Maj. G. L. Gillespie, Corps of Engineers, September 25, 1879.

No.	Names and residences of bidders.	200 feet pile dike (more or less).	Extra work if required.			Total.
			100 tons stone (in place), more or less.	1,000 feet piles, more or less, in place.	1,000 feet fascines, more or less, in place.	
		Per lin. ft.	*Per ton.*	*Per lin. ft.*	*Per lin. ft.*	
1	Cook & Wetmore, Portland, Oreg.	$9 75	$0 87½	$0 10	$0 01	$19,697 50
2	Dean Blanchard, Ranier, Oreg	12 00	2 00	10	04	24,340 00
3	James B. Montgomery, Portland, Oreg	9 66	1 50	15	60	20,220 00
4	Paquet & Smith, East Portland, Oreg*	7 71	1 25	12½	03	15,700 00
5	Thos. G. Davison, Portland, Oreg†	5 00	1 00	10	02	10,220 00

* Contract awarded. † Bid rejected. Bidder and sureties irresponsible.

Abstract of bids for the construction of a pile-dam across the Willamette Slough, opened by Maj. G. L. Gillespie, Corps of Engineers, September 25, 1879.

No.	Name and residence of bidders.	700 feet pile-dam, more or less.	100 feet crib facing, more or less.	120 feet bank revetment, more or less.	Extra material if required.				Total.
					100 tons stone, more or less (in place).	1,000 feet piles, more or less (in place).	1,000 feet fascines, more or less (in place).	1,000 feet, b. m., timber.	
		Per lin. foot.	*Per lin. foot.*	*Per lin. foot.*	*Per ton.*	*Per lin. foot.*	*Per lin. foot.*	*Per 1,000 ft.*	
1	Paquet & Smith, East Portland, Oreg.*	$10 20	$50 00	$5 00	$1 25	$0 12½	$0 03	$15 00	$13,035 00
2	Thos. G. Davison, Portland, Oreg.†	7 00	32 00	3 50	1 00	10	02	15 00	8,755 00
3	Cook & Wetmore, Portland, Oreg.	13 75	45 00	6 00	97½	10	01	12 00	15,054 50
4	James B. Montgomery, Portland, Oreg.	13 80	71 70	4 50	1 50	15	60	20 00	18,290 00

* Contract awarded. † Bid rejected. Bidder and sureties irresponsible.

Abstract of contracts for the improvement of the Lower Willamette and Columbia Rivers, in force during the fiscal year ending June 30, 1880.

No.	Names and residences of contractors.	Dates of contracts.	Subject of contract.	Remarks.
1	Robert Watson, Astoria, Oreg	Aug. 2, 1879	Hire of steam-tug	Contract closes Dec. 16, 1880.
2	Paquet & Smith, East Portland, Oreg	Sept. 29, 1879	Building pile dike and dams.	Contract closed Apr. 10, 1880.

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1880.

COLONEL: I have the honor to submit the following report of operations on the Lower Willamette and Columbia for the fiscal year 1879-'80:

DREDGING.

During the month of July, 1879, the dredge was under repair. The contract for a tender was let to Robert Watson, for the tug Rip Van Winkle, for $550 per month. The repairs to the dredge were completed about the middle of August.

The scraper made for and formerly used with the dredge having proven too light was transferred to the snag-boat, and a heavier one made for scraping on the Hog's Back, where the sand is too compact to yield readily to a clam-shell dipper. The new scraper cost $365.

On September 2 the dredge began work on the bar at the mouth of the Willamette in depths ranging from 10 to 17 feet, the length of the bar being 300 feet, and continued until the 24th, completing a cut 300 feet long, 105 feet wide, and 17 feet deep at low-water, removing 5,960 cubic yards of sand. It was then taken to Saint Helen's Bar, 15 miles lower, and while undergoing necessary repairs, which consumed the remainder of the month, the scraper, drawn by the tug, was used, the result being to reduce to some extent the lumps on the bottom.

During the month of October, and until November 8, the dredge worked on this bar, removing 10,980 cubic yards of sand. The line of the cut was made to correspond, as nearly as practicable, with the direction of the ebb-current, and the channel obtained was 150 feet wide and 18 feet deep. The ranges were changed to conform to the new channel.

The dredge was then taken to Swan Island Bar, 2 miles below Portland, beginning work in 14½ feet of water on November 12, and continuing until December 3, when a rise in the Willamette made further dredging impossible, and for the time unnecessary. During the low-water of March, 1880, the dredge was repaired for work on Swan Island Bar, which, however, was not required, the river rising again. Dredging on this bar was much interrupted by repairs, by hauling out of the channel to allow vessels to pass, and by large snags and trees found imbedded in the bottom; 3,855 cubic yards of sand were excavated here.

The scraper was tried on the shoal at the head of Sand Island, in Astoria Harbor, in February, and a gain of 1 foot in depth produced, but the general result was not encouraging, the cut filling with sand in a short time. Scraping had been done to more purpose on the Hog's Back in December, gaining 18 inches depth opposite beacon F, shown on the United States Coast Survey charts, but was discontinued during the cold weather, when an ice blockade seemed certain to occur. The whole amount of work done by the dredge during the year has been—

	Cubic yards.
At the mouth of the Willamette	5,960
At Saint Helen's Bar	10,980
At Swan Island Bar	3,855
	20,795

Number of days, of 10 hours, worked during the season, 41.6.

SURVEYS.

Swan Island Bar was surveyed in October, 1879, and again in March, 1880. The first showed a uniform least depth of 14½ feet at low-water for 400 feet, and a width of 200 feet between the 15-foot curves.

The point of least depth was formed just above the middle black buoy (No. 3). Be-

low this there was a uniform depth of from $15\frac{1}{2}$ to $16\frac{1}{2}$ feet. The eastern bank of the river had lost from 10 to 30 feet by erosion of the current since November, 1878. The second survey, in March last, showed a ruling depth of $16\frac{1}{2}$ feet, a width of channel between 15-foot curves of from 60 to 150 feet, and 2,300 feet distance between 18-foot curves in the axis of the channel. The narrowest point was found at buoy No. 3. On this occasion the soundings were extended to Weidler's Mill, at the northern boundary of Portland, 1 mile above the head of the bar, where the depth is 31 feet along the eastern shore, the depths increasing uniformly from the head of the bar up stream; and the shore lines on both sides of the river opposite the bar were surveyed, and bench marks which had been blown or washed away were replaced. A fog beacon, formed of a group of piles wrapped with chain, surmounted by cross-bands, was erected at buoy No. 3, under orders from the light-house inspector.

In October, 1879, before beginning the dam across Willamette Slough, careful soundings over Post-Office Bar and at the mouth of the Willamette showed a ruling depth of $16\frac{1}{2}$ feet at the former and of 17 feet at the latter point. In March, 1880, after completing the dam, the depth at Post-Office Bar was found to be $18\frac{1}{2}$, and at the mouth of the Willamette 21 feet at low-water.

The charts of all of the above surveys have been completed and submitted.

IMPROVEMENTS.

In answer to advertisements, proposals were submitted and opened September 25, 1879, and the contract awarded to Messrs. Paquet & Smith, of East Portland, the lowest responsible bidders. Preparations for work were made at once, and within six days the cribs for the dam across Willamette Slough were begun. The dam crosses the slough at right angles to the current 1,500 feet below the head of Sauvie's Island. It consists of two rows of piles, driven practically without interval, 10 feet apart from center to center; each row having two courses of waling-timbers 6 by 12 inches spiked to each pile with two drift-bolts $\frac{3}{4}$-inch square and 18 inches long; with cross-ties also 6 by 12 inches dovetailed between the waling courses at intervals of 12 feet; strengthened by tie-rods of $1\frac{1}{4}$-inch round iron alternating with the cross-ties, passing through waling and piles; and filled with fascines and stone to the level of the upper waling course, which is 2 feet above mean low-water level. An opening 100 feet wide, revetted with cribs, was left for a steamboat channel through the dam, between its center and the convex shore, this point being selected with a view to securing a direct channel-line for towing rafts of saw-logs, which are sometimes over 1,000 feet in length.

The slough, where the dam crosses, is 800 feet wide and from 14 to 18 feet deep at low-water. Its banks are composed of mud, compact and tough, not easily eroded. The bottom generally is of the same material, but of varying hardness, containing some layers of sand, alternating with soft silt, in which a number of large trees were encountered at various depths. From low-water mark the banks slope back at an angle of 15° to 20 feet, then rise vertically 8 feet to the river flat.

The piles used were of yellow fir, straight, free from knots, and in all respects excellent for the purpose; from 30 to 40 feet long, and from 12 to 20 inches in diameter at the butts. They were driven with the bark on, and their ends left square, having been found to keep the line better in this shape than when pointed, and their heads were banded to prevent splitting. (It was observed that piles driven without bands suffered less injury from a flat-faced hammer weighing 3,300 pounds than from one with a concave face weighing 2,000 pounds.)

The cribs, 50 feet long, 25 feet wide, and $14\frac{1}{2}$ feet high, were made of fir timbers 12 by 12 inches square, bolted with $\frac{3}{4}$-inch square drift-bolts, driven through two courses and 8 inches into a third, the four bottom courses having, in addition, screw bolts of 1-inch round iron, with their heads and nuts countersunk into the timbers. They were substantially the same as those designed by Major Houston, Corps of Engineers, the dimensions being modified to suit local requirements, having near the bottom a grillage of 12 by 12 inch timbers, with openings $2\frac{1}{2}$ by 3 feet square to permit the smaller stone to pass through freely.

Fascines were made of willow and cottonwood saplings from $\frac{1}{2}$ inch to 2 inches in diameter, compressed by means of fascine-chokers, bound with bale rope at intervals of 4 feet; crooked branches lopped off, forming compact bundles of from 8 to 10 inches diameter, and from 12 to 20 feet long.

The stone used varied in size from $\frac{1}{4}$ to 3 and 6 cubic feet, and was principally basalt from the banks of the Willamette and Columbia Rivers, obtained by blasting or collected along the shore. A portion was ship ballast. The work of building the dam was begun by revetting the banks with a row of piles driven close together outside of and parallel to low-water mark for 35 feet above and below the axis of the dam; then deflecting 20° towards the shore, and carried up on the sloping beach 2 feet above low-water mark. These were afterwards sawn off, and secured by waling-timbers dovetailed into the waling-courses at the ends of the dam.

Piles were then driven around the rectangular spaces intended for the cribs on three

sides, leaving the up-stream ends open to admit the cribs. Over these spaces and the interval between them—the prospective steamboat channel—stone was dumped from the barges to a nearly uniform depth of 3 feet to serve as a foundation for the cribs, and to protect the bottom of the channel from erosion.

The cribs were then floated into their places between the piles, moored and adjusted in lines by means of ropes, and sunk by piling stone on temporary platforms of plank laid on their corners, until they rested on the rubble previously thrown in. Small stone was then thrown into the cribs until they were filled to the level of the grillage course, then larger stone, which, catching on the grillage, held the cribs down. Care had been used to keep them level while sinking; and although the stone subsequently added to fill them caused them to settle from 6 to 8 inches, pressing the rubble foundation into the bed of the stream, their copes remained level within 3 inches.

The shores and boat channel, the points most liable to injury from the increased current which would result from the contraction of the water-way in closing the dam, having been thus made safe, work in the dam proper was begun. Only two pile-drivers could be obtained at the time. These were set to work, one behind each crib, working towards the shores, and continued day and night, using at night lanterns, suspended to line stakes on shore and on the cribs, until the dam was closed. The piles penetrated easily under from 15 to 30 blows of the hammer falling 20 feet, to depths of from 10 to 15 feet into the bottom. Where the bottom was very soft I have seen piles sink 4 and 5 feet under the simple weight of the 3,300 pounds hammer. On hard spots, probably layers of sand, from 8 to 12 blows were required to drive a pile 2 feet. Where trees imbedded in the bottom were encountered, the piles would either break through them or glance off several inches to one side. In such cases the piles were afterwards drawn into line with clamps before being bolted to the waling. As fast as the piles were driven they were sawed off at the proper level, the lower waling course bolted on, and the tie-rods put in and tightened up to hold the two rows together preparatory to filling; and the bottom in front of the piling and back of the cribs was revetted with stone to a depth of 6 feet, forming a continuous wall along the base of the dam and across the channel from shore to shore; stone to the depth of 3 feet was also spread over the bottom in the approaches to the boat channel, for 30 feet above and below the cribs.

The obstruction to the current presented by the dam at this stage of progress was sufficient to divert more than half of the volume of the Willamette into the main channel east of Sauvie's Island, causing a slow outward current during ebb and at low tide, over Post-Office Bar, where before beginning the dam slackwater prevailed at these stages.

The plan contemplated filling the dam with fascines and then adding stone to compress them until they would sink no farther, which was estimated to require a course of stone 3 feet thick. The fascines were found, however, not to sink readily, owing to their lightness and to the upward course of the current through the dam, caused by the sloping wall of rubble in front; and as there was no time to lose, the season being far advanced, and rainy weather, to be followed by floods which would surely impede, and might possibly injure seriously, the work, it was decided, after fascines had with difficulty been laid on the bottom to a depth of 6 feet, to complete the filling with stone, which could be done rapidly, and pay the contractors the excess in the price of stone over fascines. The cross-ties and upper waling course were then put in place, and the stone brought to a level at the top of the dam, and the shore revetments filled and leveled. The strips of sloping beach between the revetments and vertical banks were then covered with a layer of fascines laid oblique to the current, held down by battens 3″ × 1″, laid on edge, spiked to posts 2″ × 4″, driven 4 feet into the ground and covered with stone to the depth of 1 foot.

Beacons, composed of groups of piles bound with chain, with cross-boards reaching to the height of highest summer floods, were placed at each end of the east crib, next to the channel, to mark the passage when the dam is covered. Later a steamer, with a wood barge alongside, having been injured by collision with the cribs while passing between them at low-water, fender piles were driven against the faces of the cribs and left standing 14 feet above low-water, making a recurrence of such an accident impossible in future. The width of channel between the fenders is 97 feet, and its depth 10 feet at low-water.

By request of the parties interested a group of piles was driven 150 feet above the cribs, in line with the beacons, to facilitate the passage to small tugs ascending with heavy barges during strong ebb-tides.

From time to time, during the winter, stone was added to complete the riprap along the dam and around the cribs to an average height of 4 feet below low-water, and in the boat channel, where the sluice is strongest, to afford additional protection to the bottom.

The dam was begun October 14, and was practically completed November 20. During its construction the height of water varied from 0.7 to +2.0, reaching +3.0 during spring-tides. So low a range at this season was unparalleled, and contributed

materially to the success of the work. Ordinarily during the months of October and November occur rises of several feet in the Willamette, sufficient to necessitate suspension of the work and probably, in its unfinished state, to cause serious injury.

Up to the first of last April, when the river began to rise, the changes observed, which may be taken as the first results of closing Willamette Slough, were the following:

A difference of 0.7 foot between the height of the surface of water above and below the dam at low-water, and during ebb-tide, producing slackwater below the dam as far down as Saint Helen's, where the slough enters the Columbia, reducing the running time of steamers ascending by from half an hour to an hour;

A raising of the low-water surface at the head of Sauvie's Island, 1,500 feet above the dam, causing a continuous current outward over Post-Office Bar and through the mouth of the Willamette, where formerly low and ebb tide was accompanied by slack-water, and flood-tide by a current inward; and a gain in ruling depth of 2.0 feet at the former point, and of 3.5 feet in depth and 200 feet in width at the latter;

A general shoaling below the dam of from 6 to 8 feet, principally near the cribs, and of from 3 to 5 feet above the dam between the cribs and the shores; and an inclination of the current of the Willamette towards its eastern bank, from Gatton's Slough, a mile above the head of Sauvie's Island, to its mouth.

It is natural to expect that the benefit of the dam will extend to Swan Island Bar, 6 miles above; as the volume of water ascending the river during flood-tide has been increased by not less than 100,000 cubic feet per minute, which was formerly lost through the slough, as well as by the additional depth of the tidal prism gained by erosion on Post-Office and mouth of Willamette Bars.

As the ebb-current over these bars, caused by the dam, is strong enough to prevent deposit during ebb-tide, the depth will probably increase until the river shall have established a new regimen in this section.

MOUTH OF WILLAMETTE.

The improvements here consist of a dike (not yet completed) across Coon Island Slough, the most westerly of the three mouths of the Williamette, and revetment of the eastern shore of Coon Island from its head to the junction of the middle and principal channel of the Willamette with the Columbia.

In all details of construction the dike is identical with the dam across the Willamette Slough, and was joined to the shore by extending the front row of piles, revetted with stone, in a direct line to 2 feet above mean low-water mark on the beach. Beyond this the beach was protected from injury from the swell of steamers by fascines secured as above described in simliar work at Willamette Slough, to a height of 4 feet above low-water mark. The height of the section of dike built varies from 7 to 14 feet,

The revetment of Coon Island was extended around the head of the island 50 feet down the slough to afford protection until the completion of the dike. It corresponds with the dam in every respect, except that in the back row the piles are 12 feet apart. The irregular space between the revetment and the shore, formed by the indentations in the latter, were partially filled with brush cut from the bank of the island, covered with stone to protect the rear of the piling from the current of the Columbia, which during floods passes over the revetment nearly at right angles to its axis.

The depths immediately in front of the revetment vary from 6 to 18 feet, except at its head, where the currents of the Columbia through Percie's Slough and the mouth of the Willamette meet during floods. Here the depth is 24 feet.

Work at the mouth of the Willamette was begun November 5, as soon as pile-driving had been finished at the slough, and urged as fast as the weather and stage of water would permit until the end of March, completing the revetment as far as is at present contemplated, the dike as far as possible, and the shore connections of the latter; when operations were suspended for want of funds; first closing the unfinished end of the dike with a double row of piles, to which waling timbers were bolted, and revetting the piling throughout with stone.

The revetment stands 4 feet above low-water, the height deemed necessary to protect the banks from the swell of steamers passing closeto the island, the principal cause of the waste of the eastern shore line, which has amounted since 1873, as shown by the surveys made under the direction of this office, to more than 100 feet, corresponding to an area of 5 acres destroyed in the last seven years. This wasting process is now entirely arrested.

The amount of work done here was 597 linear feet of dike, 1,386 linear feet of revetment, 85 linear feet of shore protection at heel of dike, and 374 linear feet protection of beach at low-water line; in all, 2,443 linear feet.

The length of dike yet to build in order to join the revetment at the head of Coon Island is 980 feet, in depths varying, according to soundings made in March, from 5 to 10 feet for 700 feet, and from 20 to 26 feet for 280 feet. As these depths are likely to

change materially during the present flood in the Columbia, no accurate estimate can be made of its cost at this time.

By the end of March the bay behind the dike had shoaled materially, the low-water line making out so as to cover the single row of piling and in part the lining of the beach, and the willows in the latter have sprouted and promise to form a living hedge.

The widening of the channel in the direction of Nigger Tom Island enables the Upper Columbia steamboats to pass above the outer buoy, saving distance. The gain in depth at the mouth of the Willamette, as has been above stated, is 3¼ feet.

During the time that work was going on here the height of water ranged from —0.8 to +4 feet, reaching +8 feet on two occasions, when the Willamette was in flood, coincident with backwater in the Columbia, the latter due to the impounding of the tides in Astoria Bay by high southerly winds. This coincidence was fortunate, as the strong current of a flood in the Willamette alone would have impeded and probably seriously damaged the works. As it was, operations were suspended for days together on several occasions by high winds preventing towing of barges with stone, and by the unusual cold which for several days in the latter part of December was so severe that laborers refused to work, the thermometer ranging from +3° to +15°.

From the 22d of December until early in January the Columbia, above the mouth of the Willamette, was closed by ice. Between Portland and Astoria the river boats and ocean steamers made regular trips, the former for several days passing through Willamette Slough for fear of the ice gorge at Willow Bar, 6 miles below the mouth of the Willamette. The apprehension, however, was not realized.

On the 9th of January a tornado from the south swept the Willamette and Lower Columbia valleys, felling large quantities of timber, destroying buildings and several lives. The velocity of the wind was from 40 to 60 with occasional gusts of 70 miles per hour. The storm lasted from 11 a. m. to 2 p. m. The falling barometer having given warning of danger the river craft generally was made secure and sustained no material injury.

The stone used in filling and revetting was of several kinds. The contract providing for payment of stone by weight, the ratio of voids was measured with water, giving a mean of 0.3995, and the specific gravities by weighing fragments of stone, dry and immersed. The densities found were—

		Pounds.
Close-grained basalt, specific gravity 2.701;	weight per cubic foot	168.36
Honey-combed basalt, specific gravity 1.944;	weight per cubic foot	121.21
Sandstone, specific gravity 1.945;	weight per cubic foot	121.28
Quartzose rock, specific gravity 2.117;	weight per cubic foot	131.94
Average weight per cubic foot of all the stone used		158.68

The quantities of the several kinds of material employed were—

71,350 linear feet of piles.
79,162 feet, board measure, of sawed timber.
14,790 pounds of iron, in tie-rods.
58,900 pounds of iron, in drift-bolts.
540 pounds of iron, in screw-bolts.
9,200 fascines, average length 17 feet.
39,518 tons of stone.

The cost of the works was—

At Willamette Slough	$31,781 61
At the mouth of the Willamette	26,233 32
Total	58,014 93

This report has been made full in detail in the hope that it may be useful to others having charge of similar work. The drawings, general and detailed, are submitted herewith.

On the 15th of June the currents were observed and soundings taken in the vicinity of the improvements. The current from the Columbia struck the revetment near its lower end and separated, half going down the Columbia, the other half entering the Willamette, flowing at the rate of 2 miles per hour along the revetment to its head, then doubling round into Coon Island Slough, uniting with the water from Percie's Slough, running at the rate of from 2½ to 3 miles per hour. Soundings in the ship channel, in front of the dike and revetment, where there was scarcely any current, showed a deposit of from 1 to 2 feet since March. The depths immediately in front of the piling, and in the line of proposed extension of the dike, are unchanged.

Between the mouth of the Willamette and the head of Sauvie's Island almost perfectly slackwater prevailed. Over Post-Office Bar there has been a deposit of about 18 inches, since the beginning of the flood in April, in the ship channel.

In the Willamette Slough numerous soundings above and below the dam, and be-

tween the cribs, where the current is strongest, running at the rate of 3 miles per hour, failed to discover any cutting or other indication of injury to the work.

At the then prevailing stage, 20 feet above low-water, the dividing line between the backwater from the Columbia and the volume brought down by the Willamette, plainly marked by the muddy color of the former, crosses the channel diagonally from a point on the east shore ½ a mile above the mouth of Gatton Slough to near the head of the Willamette Slough, where the Willamette water flows over the bank and across the neck into the slough just above the dam, where it joins the backwater from the Columbia, which enters the slough with a slow current at its head.

The break or fall in the surface of water, over the dam, was about 2 inches.

STAGES OF WATER DURING THE YEAR.

The profile of water curves, drawn from daily readings of the gauges at Portland and Saint Helen's, herewith submitted, exhibits an uncommonly low average level throughout the year, except during the summer flood of the Columbia.

The principal turning points are:

AT PORTLAND.

	Feet.
June 10, 1879	20.5
July 1, 1879	19.2
September 15, 1879	3.2
November 1, 1879	1.5
November 16, 1879 (due to rain in Willamette Valley)	7.5
November 28, 1879	1.6
December 9, 1879 (due to rain in Willamette Valley)	10.0
December 25, 1879	1.5
January 9, 1880 (due to rain in Willamette Valley)	15.7
February 9, 1880	2.4
February 17, 1880 (due to rain in Willamette Valley)	7.0
March 23, 1880 (lowest level during fiscal year)	1.3
April 1, 1880 (rain in Willamette Valley)	5.0
April 7, 1880	3.8
April 16, 1880	8.0
April 22, 1880	6.5
May 8, 1880 (high-water in Columbia and Willamette rivers)	15.6
May 15, 1880 (high-water in Columbia and Willamette rivers)	12.2
June 30, 1880	27.1

AT SAINT HELEN'S.

June 10, 1879	16.5
July 1, 1879	15.6
September 15, 1879	1.8
November 1, 1879	0.3
November 13, 1879	4.0
November 27, 1879	0.4
December 16, 1879 (flood in Willamette)	6.5
December 25, 1879	1.3
January 9, 1880 (flood in Willamette)	9.2
February 1 to April 1, 1880	from 1.0 to 3.6
April 9, 1880	1.5
June 30, 1880	21.3

At this time, June 30, the river is within — feet of its height in 1876, and is still rising, but at a slower rate than during the last three days; and telegrams from the mouth of the Snake River indicate a probable fall here within the next two days. The maximum heights reached by the summer floods since the water gauge was established here have been: in 1876, 28.2; in 1877, 4.1; in 1878, 14.7; in 1879, 20.5; and in 1880, so far —.

It is not improbable that this height may yet be exceeded, a comparison of the profile of the water curves during the last five years showing that the flood volume of the present year up to this date is much less than in 1876 and 1879, while the snow-fall of the last winter is generally stated to have been greater than ever known before.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major of Engineers, U. S. A.

CONDENSED HISTORY OF THE IMPROVEMENT OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS, FROM PORTLAND, OREGON, TO THE SEA.

The Columbia is first mentioned by Jonathan Carver, in 1768, as a stream rising on the western slope of the lands dividing the tributaries of the Gulf of Mexico from those of the Pacific Ocean, called the "Oregon, or River of the West," his information being obtained from Indians and traders, although Martin d'Aguilar reported to have found in 1603 a large river emptying into the Pacific in latitude 43°, which was called the "River of the West." It was called by Heceta, who discovered but did not enter in 1775, "Assumption Inlet," "Euseñade de Heceta," and afterwards the "Rio de San Roque." In 1789 Meares called it "Deception Bay." Its Indian name was Shocatillum.

It was first entered in 1792 by the ship Columbia, Captain Gray, who gave to the river its present name, and to the bay opposite Tongue Point his own. In the same year, from information given by Captain Gray, the celebrated navigator, Admiral Vancouver, English Navy, visited the river, and his lieutenant, Broughton, ascended in small boats to where the town of Vancouver now stands. In 1811 the Tonquin, sent out by Jacob Astor from New York to establish a center for the fur trade of the northwest, entered the Columbia through the north channel and anchored in Baker's Bay.

It has not been possible to give a connected history of the navigation of the Lower Columbia and Willamette Rivers up to the present date from the imperfect records accessible. The trade of these rivers was carried on exclusively in sailing craft, principally those belonging to the Hudson's Bay and Northwestern Companies, until 1850, when steam navigation was introduced by the Columbia, a side-wheel steamboat, 90 feet long, of about 40 tons burden, built at Upper Astoria, and run between Astoria and Portland, consuming about 24 hours each trip. The Lot Whitcomb, 160 feet long, 600 tons burden, was built at Millwaukie, on the Willamette, the same year. In the fall of 1851 the Willamette, a large iron steamer, owned by the Pacific Mail Steamship Company, was put on between Astoria and Portland, running in connection with the company's San Francisco steamers. She proved too large for the trade, and in 1852 was taken off the route. In the same year 3 small steamers, 2 of iron, 1 of wood, were brought out in sections from New York and set up at Oregon City. Others, brought from abroad or built here, were added year by year until 1860, when the Oregon Steam Navigation Company was organized. This company consolidated the river trade, building new boats yearly until 3 months since, their fleet, numbering over 30 steamboats and barges, was sold to the Oregon Railway and Navigation Company, besides their other property, including the portage railways at the Cascades and Dalles and the steamboats navigating the Upper Columbia and Snake rivers.

The Columbia above Vancouver is navigable for river steamboats of large size. The lower section, of which the Willamette below Portland is, in virtue of its great width and depth, a continuation, is a channel for sea-going vessels, known as the "Lower Willamette and Columbia, from Portland to the sea." The first appropriation for its improvement was made in the river and harbor act dated June 23, 1866, amounting to $15,000.

For two years previous to this time the city of Portland had owned and operated a dredge, excavating and pulling snags at the mouth of the Willamette and on Swan Island Bar, principally the latter, where

the material excavated was hard blue clay. The city bid for removing the bar, but the price bid exceeding the appropriation, the city offered the use of the dredge free of cost, provided the government would keep it in repair. The engineer in charge of improvements of rivers in Oregon, Major R. S. Williamson, Corps of Engineers, accepted the offer, work to begin in August, 1867, at low-water. Up to this time no surveys had been made on the Lower Willamette and Columbia, except one of Swan Island Bar, by the city of Portland.

The sum expended during the fiscal year was $871.49.

1867–'68.

(Officer in charge, Maj. R. S. Williamson.)

Amount appropriated by act of March 2, 1867	$30,000 00
Expended during fiscal year	25,284 49

In the fall of 1867 dredging was done on Swan Island Bar, and snags removed from the same point and from the mouth of the Willamette.

At Swan Island Bar 18,184 cubic yards of material were excavated, at a cost of $10,484.48, opening a channel 100 feet wide, 900 feet long, and 15 feet deep at low-water. Work was resumed in February, 1868, and continued until April, opening 331 feet additional length of channel of the same width and depth, excavating 7,320 cubic yards of material, at a cost of $4,607.19.

1868–'69.

(Officer in charge, Maj. R. S. Williamson, Corps of Engineers.)

Sum appropriated by act of July 25, 1868	$21,000 00
Expended during fiscal year	26,414 28

Swan Island Bar and the bar at the mouth of the Willamette were dredged and snags removed. Surveys were made of the Willamette Slough and the mouth of the river; dredging continued on Swan Island Bar, where the depth at low-water, reduced by shoaling during the prevalence of backwater from the Columbia, was increased to 15 feet. Large trees imbedded in the bottom retarded the work very much, frequently breaking the machinery.

1869–'70.

(Officer in charge, Maj. R. S. Williamson, Corps of Engineers.)

Sum allotted, act of April 10, 1869	$13,365 00
Expended during fiscal year	15,877 76

During the year a channel 17 feet deep at low-water was opened through the bar at the mouth of the Willamette, and one of the same depth for 705 linear feet on Swan Island Bar, leaving the remainder of the bar with 15 feet depth. Twenty snags were removed from the mouth of the Willamette, and 7 from Swan Island Bar. Fourteen thousand eight hundred and eighty-seven cubic yards were dredged, at a cost of $15,877.76 for operating and repairing the dredge. The work was done by hired labor. A survey was made of the bar at the mouth of the Willamette.

1870–'71.

(Officers in charge—to April 11, 1871, Maj. R. S. Williamson; after that date, Maj. H. M. Robert, Corps of Engineers.)

Sum appropriated by act of July 11, 1870	$31,000 00
Expended during the fiscal year	24,329 48

Operations were confined to dredging on Swan Island Bar, where 1,400 cubic yards were removed. The channel cut was 17 feet deep at low-water, and 85 feet long, 2,000 linear feet yet remaining to be cut through, with a width of from 200 to 250 feet. Saint Helen's Bar, on the Columbia, 15 miles below the mouth of the Willamette, began to offer serious obstruction, making it necessary to lighten ships before they could ascend higher. At the mouth of the Willamette the same difficulties occurred. The officer in charge recommended the construction by the government of a more efficient dredge.

1871–'72.

(Officer in charge, Maj. H. M. Robert, Corps of Engineers.)

Sum available July 1, 1871	$17,970 20
Sum expended during fiscal year	14,115 40

Dredging was carried on with the old dredge belonging to the city of Portland, at Swan Island Bar and the mouth of the Willamette, excavating 27,258 cubic yards and many large stumps and trees, some of which required the services of a diver. The bars were dredged to a depth of 15 feet, and the work of cutting a channel 17 feet deep on Swan Island Bar continued. A survey was made of Saint Helen's Bar, on the Columbia, showing a channel 400 feet wide, with 16 feet of water at lowest stage.

1872–'73.

(Officer in charge, Maj. H. M. Robert, Corps of Engineers.)

Sum appropriated by act of June 10, 1872	$50,000 00
Expended during fiscal year	46,330 08

A cut, 4,400 feet long, 100 feet wide, and 17 feet deep at low-tide, was finished across Swan Island Bar during the working season of 1872; and a channel 15½ feet deep at low-water was reopened across the bar at the mouth of the river, with the old dredge; and a large snag removed from Swan Island Channel. The total volume dredged during the year was 25,725 cubic yards.

A new dredge was built and the old one put in repair and turned over to the city of Portland. The new dredge is 85 feet long, 30 feet wide, having accommodations on board for a crew. There are two dump-scows, 70 by 20 by 7 feet, capable of carrying 100 cubic yards each. The dredge and scows cost $36,482.92, currency. The dipper is of the clamshell pattern, holds 1½ cubic yards, and can be used at a depth of 35 feet, enabling work to begin earlier in the season than with the old dredge.

Saint Helen's Bar was surveyed, and found to carry 15 feet at low-water, the channel being not more than 100 feet wide.

1873–'74.

(Officers in charge—to October 22, 1873, Maj. H. M. Robert; after that time, Maj. N. Michler, Corps of Engineers.)

Sum appropriated, act of March 3, 1873	$20,000 00
Expended during fiscal year	14,678 15

The new dredge was operated at the mouth of the river, opening a channel 1,800 feet long and 120 feet wide. At Post-Office Bar, 2½ miles above, a cut was made 1,552 feet in length, 30 feet wide, and 17 feet deep at low-water, and buoys placed to mark the channel. Thirteen thousand six hundred and fifty cubic yards of material were removed.

Under contract with J. L. Hallett, dated April 21, 1874, a dam was begun across Percie's Slough, an arm of the Columbia, through which (during the annual flood of this stream, the Willamette at such times being low) a large volume of water, charged heavily with sediment, flows across the Willamette near its mouth and out through Coon Island Slough into the Columbia again. This is considered an important agent in the formation of the bar at the mouth of the Willamette.

A survey was made of the Hog's Back Bar, between Tongue Point and Woody Island, at the head of Astoria Bay; and the bar dredged, increasing the depth from 10½ to 14½ feet; and a beacon and buoys placed to mark the channel.

1874–'75.

(Officer in charge, Maj. N. Michler, Corps of Engineers.)

Sum appropriated by act of June 23, 1874	$20,000 00
Sum expended during fiscal year	13,374 26

During the year the dredge was operated on Swan Island and Post-Office bars in the Willamette, at the mouth of the Willamette, and on Saint Helen's and Hog's Back bars in the Columbia.

The cut on Swan Island Bar was 602 feet long, 35 feet wide, and 17 feet deep at low-water, the object being to remove the deposit of the last year. The entire channel as dredged to that date was 4,000 feet in length, 100 feet in width, and 17 feet in depth. Buoys were placed on this channel.

At Post-Office Bar a cut 810 feet long, 100 feet wide, and 18 feet deep was gained and marked with buoys. At the mouth of the Willamette the cut opened was 234 feet long, 110 feet wide, and 17½ feet deep. The pile dam across Percie's Slough was completed, but, owing to a number of adverse circumstances, succumbed to the flood of this year.

Dredging at Saint Helen's Bar was not begun until March, 1875, and was interrupted by high water when the length of cut had reached 600 feet. At the Hog's Back 1 foot in depth had been gained by the scour through the cut dredged the previous June; and soundings made preparatory to dredging discovered a new channel, carrying 17½ feet of water at low-tide, north of the Hog's Back.

1875–'76.

(Officers in charge—to December 28, 1875, Maj. N. Michler; after this date, Maj. John M. Wilson, Corps of Engineers.)

Sum appropriated by act of March 3, 1875	$20,000 00
Expended during fiscal year	17,532 50

The operations of the year consisted of dredging on Post-Office Bar, at the mouth of the Willamette, and on Saint Helen's Bar. Surveys were made at these points. In the fall of 1875 scraping was tried on Saint Helen's Bar without satisfactory results. The dredge was then set to work, and after thirty days' dredging had removed 7,400 cubic yards, cutting a channel 35 feet wide by 18 feet deep half-way through the bar. In the following spring dredging was resumed, completing the cut across the bar, which was 750 feet long, 35 feet wide, and 19 feet deep at low-water. The total volume excavated here during the year was 15,402 cubic yards. The sand here was so fine that the gates of the dump-scows had to be temporarily calked with old gunny sacks to prevent it from escaping. At the mouth of the Willamette a cut 590

feet long by 70 feet wide and 17 feet deep was dredged, removing 5,650 cubic yards of sand.

Post-Office Bar, in September, 1875, was found to have filled more than 3 feet during the year. Dredging was begun in October, and 600 cubic yards of sand removed; but work was stopped by high water on the last day of the month.

1876-'77.

(Officer in charge, Maj. J. M. Wilson, Corps of Engineers.)

Amount appropriated by act of August 14, 1876	$20,000 00
Expended during the year	10,508 70

Dredging was carried on at Swan Island and Post-Office bars, and at the mouth of the Willamette; and surveys made of the Willamette from Portland to its mouth, of Willamette Slough, and of Saint Helen's and Snag Island bars.

From Swan Island Bar 4,475 cubic yards of mud, sand, and gravel were removed. At Post-Office Bar a cut, 3,000 feet long, 40 feet wide, and 17 feet deep at low-water, was made, removing 10,935 yards of mud and sand. At the mouth of the Willamette the cut was 700 feet long, 100 feet wide, and 16½ feet deep; 5,875 yards of sand was excavated.

The snow-flood of 1876 was the highest since 1850, culminating at 28.2 feet above low-water mark at Portland on June 28; causing a deposit of sediment on the Lower Willamette bars from 3 to 6 feet thick.

In August, 1876, the project for the improvement of the Lower Willamette and Columbia, from Portland to Saint Helen's Bar, was submitted to the Board of Engineers for the Pacific Coast, convened for this purpose in Portland, and approved with some modifications. The project contemplated the following described works:

A dike across the west channel of the Willamette at Swan Island;

The partial closing of Willamette Slough, leaving a steamboat channel for navigation of the slough, important at all times, and especially so when the Columbia above Saint Helen's is clossed by ice; dikes and revetment at the mouth of the Willamette to confine the current to the principal channel; and

Converging dikes on Saint Helen's Bar, to contract the volume in the ship channel; also the removal of a portion of Warrior Rock, a ledge of basalt which projects from the west shore, ½ a mile above the bar, into the Columbia, deflecting the current from the ship channel across the bar.

1877-'78.

(Officer in charge, Maj. J. M. Wilson, Corps of Engineers.)

Sum available, being unexpended balance of appropriation of 1876	$18,584 54
Expended during fiscal year	11,772 65

The operations of the year consisted of dredging on Swan Island Bar, at the mouth of the Willamette, and on Saint Helen's Bar. These bars were also surveyed. Extensive repairs were made to the dredge and scows. The annual rise in the Columbia scarcely merited the name of flood, as it rose only to 14.7 feet at Portland. The work of the dredge was distributed as follows:

At Swan Island Bar 5,075 yards were removed, leaving a cut 16 feet deep at low-water; at the mouth of the Willamette a cut was dredged through the bar 100 feet wide, with 17 feet depth at low-water, removing 5,730 yards of sand; and at Saint Helen's Bar a cut 600 feet long,

110 feet wide, and 19 feet deep at low-water was opened, and 14,130 yards of sand removed.

At the last-named point shoaling had reduced the depth to 15½ feet. Beacons were erected to mark the new channel, with targets to mark the range by day and lights for night ranges.

Permanent bench marks for use in future for surveys and to show encroachments on the shore lines were erected at Swan Island and Post-Office bars, and at the mouth of the Willamette.

1878–'79.

(Officers in charge—until October 22, 1878, Maj. J. M. Wilson; after that date, Maj. G. L. Gillespie, Corps of Engineers.)

Sum appropriated by act of June 18, 1878	$30,000 00
Expended during fiscal year	10,104 89

The work of the year consisted of dredging at the mouth of the Willamette and at Swan Island and Saint Helen's bars, and of surveys at Swan Island, Willamette Slough, mouth of the Willamette, Saint Helen's Bar, and Maxwell's Bar, on the Columbia, 4½ miles below Saint Helen's. Water-gauges for the use of pilots of deep-draught vessels were erected near the Hog's Back, at Columbia City, Saint Helen's, and the mouth of the Willamette. The usual repairs were made to the dredge and scows.

Dredging at the mouth of the Willamette opened a cut across the bar 105 feet wide, with 17 feet depth of water, removing 4,815 cubic yards of sand and a quantity of snags and drift.

From Saint Helen's Bar 9,395 yards of material were excavated, giving a channel 100 feet more or less in width and 19 feet in depth. The cut having been made on the shortest line across the bar was oblique to the current, which soon filled it up, and opened a new channel across it with 18¼ feet ruling depth. The ranges were altered to conform to this new channel, which maintained a sufficient depth during the remainder of the season.

From Saint Helen's the dredge was taken to Swan Island Bar, and worked there for two months, removing 13,815 yards of sand, increasing the depth to 17 feet at low-water.

The survey at Saint Helen's Bar included the entire length of the bar—1½ mile—minute soundings being taken in the ship channels across its upper and lower ends. At the former were found the usual changes in contour and depth; at the latter, where no dredging had been done, but little change of shape, and a ruling depth of 16½ feet at low-water.

Maxwell's Bar was found to have a ruling depth of 19½ feet, the channel, however, presenting three knobs on which only 17½ feet existed, with deeper water between them.

A fog beacon was erected at the foot of Three Tree Island in the Willamette, ¾ of a mile above its mouth, by the inspector of this light-house district.

1879–'80.

(Officer in charge, Maj. G. L. Gillespie, Corps of Engineers.)

Sum appropriated by act of March 3, 1879	$45,000 00
Expended during fiscal year	71,711 68

Dredging was carried on at the mouth of the Willamette, Saint Helen's and Swan Island bars. At the first-named point a cut 300 feet long, 105 feet wide, and 17 feet deep was made through the bar, 5,960 yards being

excavated. At Saint Helen's Bar 1,080 yards were removed, making a cut 150 feet wide with 18 feet depth of water. At Swan Island 3,855 cubic yards were dredged, and a number of large snags imbedded in the bottom removed. Work here was stopped before completing the cut by a rise in the Willamette.

The shoals at the Hog's Back and the head of Sand Island in Astoria Harbor were scraped, but without encouraging results. Surveys were made at Swan Island Bar to direct dredging, and at Willamette Slough and the mouth of the Willamette preparatory to beginning the improvements recommended by the Board of Engineers. Of the plan adopted the portion executed during this fiscal year comprised the dam across the Willamette Slough, a dike partially completed across the head of Coon Island Slough, and revetment of the east side of Coon Island for an extent of 1,400 feet from its head down.

The dam and dike consisted of two rows of piles 10 feet apart, strengthened by waling timbers, cross-ties, and, in addition, by tie-rods extending through from outside to outside of the timbers, and filled with fascines and stone and riprapped with stone, the cope extending 2 feet above low-water mark; joined to the shore by piling carried up on the beach to the height of the cope; the shore connections revetted with fascines covered with stone. The revetment of Coon Island consists of a front row of piles driven close together, and a back row, 10 feet distant, in which the piles stand 12 feet apart; the whole strengthened, filled, and riprapped like the dike.

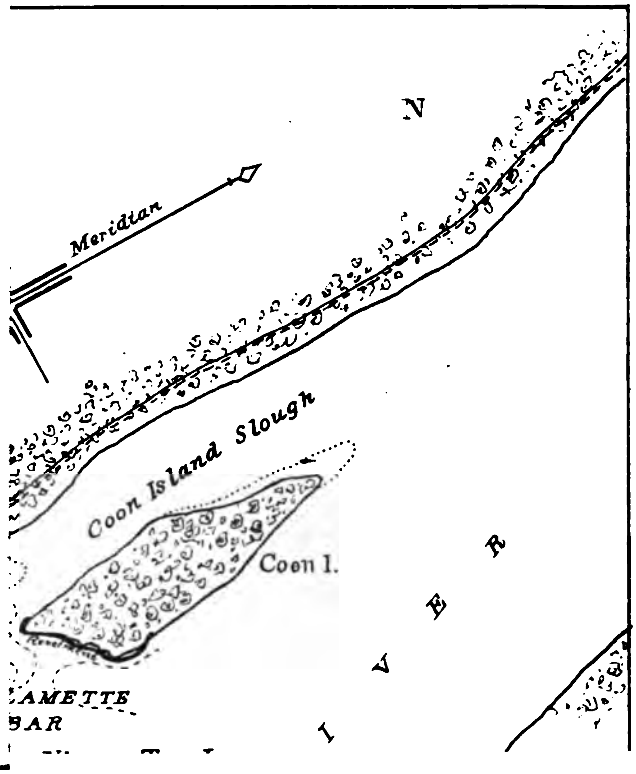
The contract was let to Paquet & Smith, of East Portland, on September 25, 1879, and work begun at once and pushed as rapidly as possible until the end of March, 1880, when it was suspended for want of funds; all, however, having been completed except a section of the Coon Island dike, 980 feet long, still required to join the revetment at the head of Coon Island.

The extraordinarily low-water which prevailed during the winter and early spring contributed greatly to the success of the work. The principal results so far have been a gain of 2 feet in depth over Post-Office Bar, and of 3½ feet in depth and 200 feet width of channel at the mouth of the Willamette. The contractors were paid up and their contract closed

In February, 1880, a fog beacon was erected by the inspector of this light-house district at Buoy No. 2, on Swan Island Bar.

During the year the depth on the river bars was such that no vessel drawing 18 feet or less grounded, except when out of the channel.

The total sum expended on the improvement of the Lower Willamette and Columbia up to June 30, 1880, has been $305,369.68, a sum small in proportion to the value of the result to be obtained, and which has been in great measure already accomplished. Before dredging was done on the bars below Portland, the ruling depth from Portland to the mouth of the Willamette was 10 feet, and thence to Astoria 15 feet at low-water; the latter controlled by the Hog's Back Shoal. Vessels were obliged to lighten at the mouth of the Willamette, and send a part of their cargo to Portland on river steamboats and barges; when outward bound they received a portion of their freight at Saint Helen's. Since beginning dredging in 1868 the ruling depths between Astoria and Portland have gradually increased to 18 feet at low-water, high-tide, except at the Hog's Back, where it is 17 feet at low-tide. From the gain in depth on Post-Office Bar and at the mouth of the Willamette, which has appeared since beginning the execution of the works of permanent improvement, it is not unreasonable to expect that the work when completed will produce such an increase of depth over the bars that the annual deposit of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sediment by the Columbia flood, which varies in depth from 2 to 4 feet, will not extend above the plane of 20 feet below low-water level; and that the fresh deposits being soft and easily eroded will, instead of remaining to build up the bars in layers, consolidating with the pressure of yearly accretions, be carried off almost as fast as the flood abates by the outward currents of the river and ebb-tides, which will increase in volume and force with the general deepening of the channel.

The annexed statement of the numbers and aggregate tonnage of vessels trading to and from Portland each year since 1866 will show the rapid growth of the commerce of this point, a growth principally due to the improvement of the river channel.

Descriptive lists of the steam craft at present running on the several lines centering at Portland, and of others formerly used, now out of service, are hereto appended, furnishing a complete roll of the steam fleet of the Columbia and its tributaries.

River and ocean steamers running June, 1880.

Names.	Built.		Hull measurement.			Tonnage (measured).	Route.
	In—	At—	Length.	Width.	Hold.		
California	1864	Mystic		....	....	673	Portland and Alaska.
Gussie Telfair	1863	Greenock		....	....	413	Coaster.
Annie Faxon	1877	Celilo, Oreg	165	37	5	709	Upper Columbia and Snake.
A. A. McCully	1877	Canemah, Oreg	140	35	5	498	Upper Willamette.
Almota	1876	Celilo, Oreg	155	36	5	502	Upper Columbia and Snake.
Bonita	1875	Portland, Oreg	152	30	6	527	Lower Willamette and Columbia.
Bonanza	1875	....do	155	35	5	651	Upper Willamette.
Calliope	1870	Corvallis, Oreg	105	24	5	143	Lower Willamette and Columbia.
Carrie Norton	1878	Canemah, Oreg	....	....	....	13	Lower Willamette.
Champion	1875	Portland, Oreg	155	35	5	634	Upper Willamette.
City of Salem	1875	....do	140	32	5	543	Do.
City of Quincy	1878	....do	109	22	4½	195	Do.
Commodore Perry	1874	....do	51	12½	5½	35	Tug. Lower Willamette and Columbia.
Dixie Thompson	1871	Portland, Oreg	155	28	6	443	Do.
Dayton	1868	Canemah	117	18	4½	202	Tug. Lower Willamette and Cowlitz.
Edith	1877	Portland	100	22½	4	74	Do.
Emma Hayward	1871	....do	175	28	7	577	Do.
E. N. Cooke	1871	Oregon City	150	26	6	416	Willamette and Cowlitz.
Gov. Grover	1873	Portland	130	32	6	404	Willamette and Columbia.
Gen'l Canby	1875	South Bend, Wash		....	....	76	Astoria and Fort Canby, Wash.
Gazelle	1876	Portland	92	18	5	157	Lower Willamette and Columbia.
Hydra	1876	Saint Helen's	69	17	2½	75	Do.
Harvest Queen	1878	Celilo	200	38	6	846	Upper Columbia.
Idaho	1869	The Dalles	140	26	6	302	Do.
John Gates	1878	Celilo	151	32	5	673	Do.
J. Ordway	1876	Portland, Oreg	131	24	6½	292	Lower Willamette and Columbia.
Latona	1878	....do		....	....	129	Portland and Lewis River, Wash.
Lurline	1878	....do	152	30	6	481	Lower Willamette and Columbia.
McMinville	1877	Canemah	135	32	5	417	Upper Willamette.
Maria Wilkins	1872	Portland	76	17	5	97	Lower Willamette and Columbia.
Mountain Queen	1877	The Dalles	175	32	7	719	Upper Columbia.
New Texino	1876	Celilo	145	32	6	462	Upper Columbia and Snake.
North West	1877	Columbus, Wash	125	30	6	356	Do.
Novelty	1877	Portland		....	.	3	Launch. Lower Columbia.
Onward	1867	Tualatin River	98	17	4	155	Lower Willamette and Columbia.
Orient	1872	Portland	150	36	5	587	Upper Willamette.
Oneatta	1872	Pioneer City	82	14½	4½	95	Astoria Harbor.
Occident	1875	Portland	150	36	5	587	Upper Willamette.
Ohio	1874	Canemah	120	28	5	346	Do.
Ocklahama	1876	Portland	157	32	7	581	Lower Willamette and Columbia.
Portland	1876	....do	60	12	6	32	Tug. Lower Willamette and Columbia.
Rescue	1864	Monticello, Wash	100	24	4½	126	Lower Willamette and Columbia.
Rip Van Winkle	1877	Astoria	....	....	....	36	Tug. Willamette and Columbia.
R. R. Thompson	1878	The Dalles	215	39	9	1,158	Upper Columbia.
Sam	1877	Portland	....	....	....	15	Launch. Astoria Harbor.
S. G. Reed	1878	....do	175	33	7	800	Portland and Cascades.
Spokane	1877	Celilo	151	32	5	673	Upper Columbia and Snake.
Traveller	1878	Portland, Oreg	125	22	4½	238	Willamette and Columbia.

River and ocean steamers running June, 1880—**Continued.**

Names.	Built. In—	Built. At—	Hull measurement. Length.	Hull measurement. Width.	Hull measurement. Hold.	Tonnage (measured).	Route.
Toledo	1878	....do	109	22½	4½	202	Portland and Cowlitz River.
Varuna	1869	Port Orchard				39	Astoria Harbor.
Willamette Chief	1874	Portland	163	36	5½	588	Willamette and Columbia.
Westport	1878	Westport				204	Lower Willamette and Columl
Welcome	1874	Portland	130	26	5½	327	Do.
Wonder	1877	....do	131	65	6¾	320	Do.
Wide West	1877	....do	215	39	8	1, 201	Portland and Cascades.
O. C. R. R. Co. Ferry	1879	....do	140	28	7		Ferries across Willamette, Portland.
Katie Ladd	1871	Westport	100	33	4½	111	Do.
Eliza Ladd	1875	Portland	91	30	5½	118	Do.
Ben Holladay	1872	....do	90	14	7	46	Tug. Lower Willamette Columbia.
Clatsop Chief	1875	Skipanon	62	15	4½	18	Do.
Columbia	1876	Knappton	193	31	10	111	Tug. Columbia Bar.
Henrietta	1869	Sucker Lake	54	12	3	45	Lower Willamette and Columl
Jane West	1872	Westport	25	7	3	13	Lower Columbia.
Eloina	1877	The Dalles	92½	20½	5	178	Upper Columbia.
Geo. W. Elder	1875	Chester, Pa	250	38½	21	1, 709	Portland and San Francisco.
Oregon		....do	283	37½	23½	2, 335	Do.
State of California	1879	Philadelphia	312	37	26	2, 200	Do.
Columbia	1880	Chester, Pa	334	38½	23	3, 000	Do.
D. S. Baker	1878	Celilo	200	38	6	846	Upper Columbia and Snake.
Veto							Vancouver Ferry-boat.
Minuet							Launch. Astoria Harbor.

STEAMBOATS OUT OF SERVICE.

Names.	Built. In—	Built. At—	Hull measurement. Length.	Hull measurement. Width.	Hull measurement. Hold.	Tonnage (measured).	Route.
Columbia	1850	Astoria	85	16	5	60	Lower Columbia and Willamet
Lot Whitcomb	1850	Milwaukee, Oreg	150	26	7	150	Do.
Willamette	1851	Wilmington, Del	160	28	7	200	Do.
Eagle	1851	Philadelphia, Pa	35	8	4	15	Do.
Black Hawk	1851	....do	30	7	3	10	Do.
Major Redding	1851	....do	35	8	4	15	Do.
Belle	1853	Oregon City	100	16	5	50	Do.
Fashion	1853	Portland	90	16	5	40	Do.
Eliza Anderson	1853	....do	125	22	10	150	Lost on Willamette Falls.
Portland	1854	Oregon City	100	18	5	75	Lower Columbia and Willamet
Jennie Clarke	1855	....do	115	18	6	100	Do.
Firefly	1855	Philadelphia	25	6	3	10	Lost on Sand Island.
James P. Flint	1852	Upper Cascade	50	10	5	20	Cascades and Dalles (explode
Cosmopolite	1852	....do	50	12	5	25	Cascades and Dalles.
Allen	1852	....do	35	8	4	15	Do.
Mary	1855	....do	75	16	5	35	Do.
Wasco	1857	....do	60	16	5	25	Do.
Umatilla	1857	....do	115	20	5	110	Lost on Cascades Rapids.
Hassaloe	1857	....do	120	20	5	112	Cascades and Dalles.
Marie Moody	1865	Pend d'Oreille Lake	100	20	5	100	Pend d'Oreille Lake.
Missoula	1866	....do	115	22	5	125	Do.
Cabinet	1866	....do	90	20	5	90	Do.
Forty-nine	1865	Colville	115	22	5	125	From Colville, Wash., 200 mi above.
Shoshone	1865	Fort Boise	145	26	5	150	Old's Ferry and Owyhee Riv sunk on Upper Willamette.
Hoosier	1851	Portland	40	10	3	25	Willamette above Oregon Cit
Canemah	1851	Canemah	90	20	5	75	Do.
Washington	1851	Philadelphia	40	8	4	20	Do.
Multnomah	1851	....do	100	18	6	75	Do.
Franklin	1852	Canemah	100	18	5	60	Do.
Oregon	1852	Fairfield, Oreg	95	18	5	55	Do.
Shoalwater	1853	Canemah	110	18	6	75	Do.
Gazelle	1853	Lynn City, Oreg	120	20	6	110	Exploded above Oregon City.
Willamette	1853	Canemah	140	26	6	150	Do.
Enterprise	1855	....do	125	28	5	125	Do.
Clinton	1855	....do					Do.
Surprise	1857	....do	140	26	6	145	Do.
Elk	1857	....do	120	25	6	100	Do.
Moose	1857	....do	110	20	5	90	Do.
Swan	1857	Moore's Mill	115	20	5	95	Do.
Onward	1858	Canemah	128	24	5	107	Do.
St. Clair	1858	....do	75	15	5	40	Do.
Yamhill	1858	....do	80	16	4	25	Do.
Enterprise	1863	....do	115	26	5	120	Do.
Pioneer	1863	....do	75	10	5	25	Do.
Success							Do.
Albany							Sunk on Upper Willamette.

DATA RELATIVE TO THE CLASS OF VESSELS WHICH CROSS THE BAR AT THE MOUTH OF THE COLUMBIA RIVER, OREGON.

All foreign trading vessels are generally of iron; American and coasting vessels generally of wood. The usual draught of the largest vessels is 20 to 21 feet; occasionally a vessel crosses out drawing as much as 23 feet.

Average tonnage of American vessels, 1,800; draught, 21 feet.
Average tonnage of foreign vessels, 1,500; draught, 20 feet.
Average tonnage of coasting vessels, 800; draught, 16 feet.

M M 2.

IMPROVEMENT OF THE UPPER WILLAMETTE RIVER.

The improvement during the year has been confined to that portion of the river embraced between Portland and Corvallis, a distance of about 114 miles, and has comprised the removal of snags, the scraping of bars, the building of temporary dams, and the cutting of timber from the banks which had either fallen or was about to fall into the channel. The amount available for the work at the beginning of the year was $14,401.51.

The snag-boat Corvallis, to which a scraper is attached, with a small crew of well-trained and experienced men, was at the opening of the year at McCloskey's Chute, a short distance below Salem, removing snags and accumulations of drift-wood, and from that time until she was withdrawn, on the 1st of October, to go into the Yamhill River, she uninterruptedly patrolled the river, from near Albany to the mouth of the Yamhill, removing snags and scraping the bars, besides building a short extent of light dam-work at Beaver and Lone Tree dams. It was found on trial that the motive power which had been put into the boat was not great enough to enable her to work with facility in scraping bars where the depth was slight and the current swift; still, the amount of work accomplished was very large and the expense much reduced. By the exercise of good judgment in limiting the depths gained by scraping to only the absolute necessities of convenient navigation over the bars, the river velocities and depths were kept within proper bounds, and the boats which used the upper river at lowest stage were able to reach all the points where any freight was to be obtained. I have the gratification of saying that no complaints have reached this office from any source relative to the existence of obstructions of any nature which were not immediately acted upon, and that throughout the year the river has been in a navigable condition equal to the wants of the country through which it passes. For the detailed service of the snag-boat, the number of snags removed, and the length of dams built, I respectfully refer to the appended report of Assistant Engineer R. A. Habersham.

Early in September several of the steamboat owners interested in the navigation of the Upper Willamette River came to this office and made the request that the government continue the improvement commenced in 1878 at Rock Island Rapids (a few miles above Oregon City), by blasting the high points at the upper end of Dove Rock down to low-water line. The old or natural channel passes on the west side of Dove Rock, and is somewhat tortuous. The government channel is on the east side, is shorter, and has ample water. The channel through the rapids, on either side of the rock, is practicable at low-water, but it was alleged by the boat owners that when the river rose 2 to 4 feet the water "drew"

over Dove Rock, and boats descending found it almost impossible to pass on either side without being thrown upon it. As the reduction of this rock had been asked, on the same grounds, by the principal pilots for several years, I felt that their application should be noticed. The subject was brought to the attention of the department by letter of September 8, and on the 20th I was authorized to make a contract with Joseph Pagnet, of East Portland, Oreg., for the removal of 500 cubic yards of solid rock, at $7.40 per cubic yard. The contract is dated September 25, 1879, and will expire October 1, 1880. Mr. Paquet was very active in making his arrangements for prosecuting the contract at once, but immediately after sending his plant to the site of the work the water rose 2½ feet, and remained up so long that it was thought best to defer all operations until the low stage of 1880.

The vicinity of Rock Island is the most dangerous part of the river, and the channel should be so improved that the commerce of the river, which is already large and is increasing annually, should have a safe outlet through the rapids day and night. To effect this result will require the removal of 600 cubic yards of solid rock in clearing away the Tualatin rocks awash at low stage, and in widening the channel at Bonanza Rock.

I renew my recommendations of last year for the building of a snag-boat for use between Corvallis and Eugene City, and for a complete survey of the river from Corvallis to Portland. The amount required for the running expenses of the snag-boat during the year is $7,000, to which I will add $5,000 for building 2,000 feet of inexpensive dams.

The appropriations made for this improvement from March 3, 1871, to March 3, 1879, inclusive, aggregate	$103,500 00
Appropriated by act of June 14, 1880	12,000 00
Making a total of	115,500 00
Of this amount there has been expended to date	97,126 84
Balance	18,373 16

It is expected that this balance will be applied in removing snags, scraping bars, and building small dams at points between Portland and Corvallis where navigation shall become obstructed, and in improving the channel through Rock Island Rapids by reducing Dove and Bonanza rocks.

The amount which can be profitably expended during the fiscal year ending June 30, 1882, is tabulated as follows:

Construction of a new snag-boat	$14,000
Survey of Willamette River from Corvallis to Portland	12,000
2,000 feet of temporary dams, at $2.50 per foot	5,000
Annual expenses for 2 snag-boats	15,000
Improving Rock Island Rapids	7,000
	53,000

This river is in the collection district of Willamette. Portland, Oreg., is the nearest port of entry, and the nearest works of defense are at the mouth of the Columbia River. There are no lights on the river, and no buoys above those at Swan Island, near Portland, are maintained at the expense of the general government.

The amount of revenue collected at the port of Portland, Oreg., during the eleven months ending May 31, 1880, is $97,441.82.

The commerce of the river is carried principally in boats belonging to the two transportation companies, called respectively the Oregon Railway and Navigation Company, successor to the Oregon Steam Navigation Company, and the Oregonian Railway (limited). The latter is a new corporation, which has lately purchased the Dayton, Sheridan and

Grande Ronde Narrow-Gauge Railroad, which is being extended up the valley on the west side, and which may eventually pass the Cascade Range at one of the southerly practicable passes. The Oregonian Railway Company (limited) has two boats which connect Dayton, on the Yamhill, with Portland.

The Oregon Central Railroad, on the west side, has been extended during the year to Corvallis, and the Oregon and California Railroad, on the east side, is now adding to its road two short feeders, which run into rich valleys on the west side of the Cascade Range, in the vicinity of Salem. These railroad extensions vastly increase the facilities for bringing the products of the valley to a ready market, but in no wise diminish the importance of the river, for it is found by experience in other localities that navigable rivers will always be used for transporting a large proportion of the commerce of their valleys, no matter what may be the extent and capacity of the railroads on the banks.

The navigation which is benefited by the improvements carried on annually extends from Portland, Oreg., to the head of navigation of the Willamette, at Eugene City, a distance of 172 miles.

It is a valley of exceeding richness and fertility, and has a thriving and industrious population, which is increasing in numbers and wealth all the time. The encouragement given to emigration to the State by the introduction of eastern capital in building and extending railroads, and increasing the number and tonnage of steam propellers and sailing vessels plying between the mouth of the Columbia and foreign and domestic ports, is having a direct influence in enhancing the values of all kinds of property, and will contribute most materially in increasing the agricultural interests which center along the main arteries of commerce.

The amount of produce and freight of every class passing through the Willamette locks, at Oregon City (owned by the Oregon Railway and Navigation Company), has not materially changed during the year.

Abstracts of proposals and contract, a statement of funds, and a chart showing the water levels throughout the year, are transmitted herewith.

Money statement.

July 1, 1879, amount available	$14,401 51	
Amount appropriated by act approved June 14, 1880	12,000 00	
		$26,401 51
July 1, 1880, amount expended during fiscal year		8,028 35
July 1, 1880, amount available		18,373 16
Amount (estimated) required for completion of existing project		51,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		53,000 00

Abstract of proposals for the removal of rock from the channel of the Upper Willamette River, at Rock Island Rapids, opened by Maj. G. L. Gillespie, Corps of Engineers, September 8, 1879.

No.	Name and residence of bidder.	500 cubic yards of rock, more or less.	Remarks.
		Per cubic yard.	
1	Joseph Paquet, East Portland, Oreg	$7 40	Contract awarded.

Abstract of contract for the improvement of the Upper Willamette River, in force during the fiscal year ending June 30, 1880.

No.	Name and residence of contractor.	Date of contract.	Subject of contract.	Price per cubic yard.	Remarks.
1	Joseph Paquet, East Portland, Oreg.	Sept. 25, 1879	Rock excavation....	$7 40	Contract expires October 1, 1880.

REPORT OF MR. ROBERT HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1880.

COLONEL: I have the honor to submit the following report of operations on the Upper Willamette during the fiscal year 1879-'80:

SNAG-BOAT.

July 1, found the snag-boat at work at McCloskey's Chute. From the 1st to the 18th was spent between McCloskey's and Coffee Slough, 10 miles below, removing snags and accumulations of drift wood. On the 18th, raking on McCloskey's Bar, to straighten the channel at the foot of the rapid, was resumed; but the boat being deficient in backing power, little impression was made on the cement gravel composing the bottom. On the 23d raking was begun on Buena Vista Bar, where three days' work increased the depth sufficiently to enable the steamboat Bonanza to haul over the bar with her capstan, and was continued until the 6th of August, obtaining 30 inches depth. More than this, in the condition of the river at that time, would have lowered the water on Luckiamute Bar, 1 mile above, where there was no depth to spare. Accordingly the boat was moved to the bar at the foot of Gervais Prairie, 15 miles below Salem, where, after six days' raking, the depth was found to be 30 inches in the steamboat channel.

The remainder of the month was spent in removing drift from Carey's Bend and Fairbanks' Landing, and in raking on Beaver Bar, with good results.

During September all obstructions were removed from the channel near Salem at Beaver Bar, McCloskey's Chute, Lone Tree Bar, Ash Island, mouth of Yamhill River, and in the Yamhill; and at Beaver and Lone Tree Bars short temporary dams were built, by placing trees along the upper side of the bars to increase the sluice, and breaches in that portion of the Lone Tree dam, which was built in 1875, repaired in the same manner. This work was performed by the crew of the snag-boat.

From the 1st to the 12th of October was spent in removing drift from the Yamhill below Dayton, 6 miles above the mouth and 46¼ miles from Portland. As there are three lines of steamers making daily trips between these points throughout the year, the maintenance of a clear channel in the Yamhill below Dayton is as necessary as in the Willamette below Salem. There being no further work required on the upper river, on the 13th the boat was ordered to Portland, and thence to the Lower Willamette, where a week was spent removing a number of large snags from the vicinity of Swan Island and the mouth of the Willamette, after which she was laid up for the winter.

The last summer's work having shown the snag-boat to be deficient in motive power, and defective as to the the shape of her hull, the square stern preventing her from backing readily when dragging the rake, and indeed at all times, during the last spring she was thoroughly overhauled, the hull altered by raising the after rake, and recaulked; the old cylinders, 8 by 36 inches, taken out and replaced by others 10 by 36; hoisting tackle repaired; all wood work repainted; and the boiler and steam dome covered with asbestos plaster. The repairs and alterations cost $1,906. The boat has gained by them 40 per cent. in speed, and 100 per cent., more or less, in backing power, and in addition the asbestos covering, by keeping the steam hot, saves fuel. No work has been done so far this summer, owing to the high stage of water. The work performed by the snag-boat during the fiscal year is as follows:

Number of snags removed	586
Number of trees cut from banks	158
Number of linear feet of temporary dams built	700
Number of days spent removing snags, &c	57
Number of days spent raking bars	23
Number of days, 10 hours each, worked	98
Number of days lost in repairs, cleaning, &c	2
Number of hours moving position	86½
Number of miles traveled	267

In February, in compliance with the request of parties interested, the master and a portion of the crew of the snag-boat were sent to cut away a number of large trees which had been prostrated by the gale of January 9, mention of which has been made in my report on the Lower Willamette and Columbia. The snag-boat being out of repair at the time, the steamboat A. A. McCully, provided with a powerful capstan, worked by steam, was hired for the work, which consumed five days. Three large snags were removed from the channel, and one hundred and forty-four trees, which were hanging over the banks, were cut away, principally at Gervais Slough, Lone Tree Bar, and Centennial Chute. Several of the trees were from 5 to 6 feet in diameter. These, having been bored two-thirds through with a $1\frac{1}{4}$ inch auger, were charged with one pound of No. one giant powder, lightly tamped with earth. They were cut in two by the explosion, a work which would have taken half a day if performed with the ax or saw.

STAGE OF WATER.

The following are the turning points in the profile of water curves, herewith submitted, at Albany, this station being selected as representing, from its proximity to the head of low-water navigation, the ruling navigable depths at different seasons better than Salem:

July 1	2.4	January 21	8.4
August 20	0.3	January 26	12.5
August 31	1.0	February 11	3.5
September 27	0.2	February 16	12.8
September 30	2.4	February 22	5.6
October 6	1.0	March 22	3.0
October 17	2.5	April 11	10.0
November 6	1.0	April 27	6.1
November 15	10.3	May 3	10.0
November 30	3.0	May 18	6.0
December 7	23.4	May 22	9.8
December 26	4.3	June 1 to 30, from	6.5 to 10.0
January 4	23.0		

The height during May and June is due to melted snow. The profile between these points is nearly uniform.

Notwithstanding the low stage of water which prevailed until late in the fall of 1879, the condition of the bars was so improved by the dams previously built, by the removal of drift accumulations during six years past, and by the recent use of the scraper, that light-draught boats could at all times ascend to Corvallis without material delay, although during portions of September and October navigation was suspended for want of freight.

IMPROVEMENTS.

In September, 1879, a contract was let to Joseph Paquet, of East Portland, for the removal of 500 cubic yards, more or less, of rock from Dove's and Bonanza Rocks, 17 miles above Portland, at $7.40 per cubic yard. Dove's Rock was surveyed, and the plant brought to the spot, ready for work by the end of the month, when a rise of 2.4 feet occurred, preventing work for the time; and as such interruptions were likely to occur from that time on through the winter, it was decided to suspend operations for the season.

LEVELS.

In July the relative elevation of the surface of water at important points between Portland and Eugene City, the head of navigation, was ascertained by leveling from bench marks on the line of the Oregon and California Railroad, kindly furnished by Mr. Koehler, the vice-president of the company. These levels gave the following profile:

Station.	Distance from Portland.	Low-water.	High-water. 1861-'62.
	Miles.		
Eugene City	172	428.031	445.531
Harrisburg	149	319.003	335.540
Albany	103	199.128	234.945
Salem	70	140.382	181.300
Oregon City, above the falls	12	77.270	96.160
Oregon City, below the falls	12	33.060	83 505
Portland		28.595	53.445

The base of levels was assumed, and has been since found to be about 23 feet too high. The actual height of low-water mark at Portland does not probably exceed 6 feet.

WORK FOR THE PRESENT SUMMER.

Besides the ordinary service of the snag-boat, repairs will have to be made to the dams at Long Crossing, Upper Fickels, and Half Moon bars, and probably at other points not discoverable until low-water. An examination of the middle and east channels leading out from the Willamette at the head of Centennial Chute, made in February last, shows that they abstract considerable volumes of water from the chute, which has for four years been used to the exclusion of the others, at low-water, and should by all means be kept open. This can best be done by closing the two minor channels by fascines and gravel dams, carried up to low-water mark, leaving them open at higher stages of water.

This work, as well as the repairs to existing dams above referred to, can be done by the crew of the snag-boat, hiring additional men for a few days. The cost, in excess of the expenses of the boat and crew for the time thus spent, should not exceed $1,000.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major, United States Engineers.

CONDENSED HISTORY OF THE IMPROVEMENT OF THE UPPER WILLAMETTE RIVER.

The Willamette River rises in the Cascade Range, about 150 miles south of its entrance into the Columbia. It is navigable during winter and spring, for boats drawing 3 feet, to Eugene City, 184 miles from its mouth, and, since its improvement, during summer and fall, for boats of lighter draft, to Corvallis, 127 miles.

A description of the physical features of the river will be found in the report of the Chief of Engineers for the year 1876.

A history of the steam navigation of the upper river up to the present date will be interesting. It was begun in 1851 by the Hoosier, a small steamboat of 25 tons burden, running between Oregon City and Dayton, on the Yamhill; followed during the winter of 1851–'52 by the Washington, which was taken up over the falls at Oregon City, and the Multnomah and Conemah, running to Corvallis, the Oregon and Shoalwater, built in 1852, the Portland and Willamette, built in 1853, the Gazelle, in 1854. These were all side-wheel boats of small size, except the Gazelle, a large and beautiful boat, which within three weeks after her trial trip exploded, killing twenty-three persons and wounding many more. All boats in use at present are of the stern-wheel model.

The first stern-wheel boat used above Oregon City was the Enterprise, built in 1855, which ran to Eugene City during high-water. In 1856 the Surprise, another stern-wheeler, was built, followed at a later date by the Success, and others. All of the above boats were built and operated by individuals, and ran principally to points below Corvallis, except during high stages. It was not until 1862 that the navigation of the Upper Willamette was undertaken by an organized company. From 1862 to 1872 the greater portion of the carrying trade was in the hands of the People's Transportation Company, running thirteen steamboats, with an aggregate tonnage of 3,727. In 1872 this company sold out to the Willamette Transportation Company. Since this time nine new boats, in all 4,705 tons, have been added to the fleet, which has twice since changed owners, passing, in 1876, into the hands of the Willamette Transportation and Locks Company, and in 1879 to the Oregon Railway and Navigation Company, the present owners of all the Upper Willamette steamboats, except four, viz, the Ohio and City of Salem, built by

U. B. Scott & Co., and now owned by the Oregonian Railway Company, limited; the A. A. McCully, built by Capt. J. D. Miller, and now belonging to Z. J. Hatch; and the City of Quincy, built and owned by Buchanan Brothers.

The most important aid to the navigation of the Willamette, as connecting the upper river with the lower and with the Columbia, is the canal and locks at Oregon City, built by the Willamette Transportation and Locks Company, and opened to traffic January 1, 1873. There are four lifts and a guard lock, with an aggregate height of 39.75 feet in a length of 3,100 feet' The locks are 210 feet long by 40 feet wide, with a depth on the miter sill at low-water of 3 feet. The works cost $600,000, and now belong to the Oregon Railway and Navigation Company, who charge 25 cents per ton for boats, and from 5 to 10 cents per passenger.

Before entering on the history of the works of improvement it will be well to describe the several localities where they have been conducted, in view of the changes which have occurred since the improvements were commenced.

The improvements made consist in general of removal of drift, blasting off ledges of rock, building of dams, and scraping on the gravel bars.

Besides the removal of snags, which has been carried on as high as Harrisburg, 149 miles from Portland, work on the bars has been confined to the section below Corvallis, the head of low-water navigation, 115 miles from Portland.

The distances of the several bars and of the principal shipping points of the Upper Willamette from Portland, the focus of the steamboat lines of the Columbia and its tributaries, are given in tabular form at the end of this report. Proceeding up stream the first difficulty in the way of navigation appears at

ROCK ISLAND.

The channel here is sinuous, winding through deep crevices in the basaltic rock composing the bed of the river. The improvements made here have consisted in blasting off portions of Dove and Bonanza Rocks, the two worst points. Additional work here is under contract, to be done during the present year.

POLALLEY BAR

is the next obstruction. The stream is divided by two islands into three channels, that in the center being the principal, that along the left shore unimportant, and the third, along the right bank, carrying about one-fourth of the river's volume. This last was closed, and on the side opposite a dam was built from the foot of Dove's Island, extending beyond the crest of the bar. Before this dam was completed to the desired length, 1877, a portion of the crew of the pile-driver struck work, and no more piles could be driven. There was no time to lose, and the remainder of the dam, 70 feet in length, was built entirely of wheat-sacks, procured from a storehouse near by, filled with gravel from the bed of the river. It resisted the current during the rest of the season, producing the desired depth. Since then this bar has given no trouble.

YAMHILL BAR

is just below the mouth of the river of the same name, the second in importance of the tributaries of the Willamette. A dam was built here in

1873, reducing the excessive width of the river, and resulting in good navigable depth, which is maintained to the present time.

UNION BAR.

Here there are two channels, that on the right called Coffee Slough; the left, formerly the principal, obstructed by a bar due to the loss of water through the other. This channel is very crooked. A dam, built here in 1873 and lengthened in 1877, caused an increase of flow through Coffee Slough, deepening and straightening that channel, which, having been kept clear of drift for the last three years, is now free from obstructions, and is used to the exclusion of the other, avoiding two bad bends, viz, Union Bar and Bennet's Dread, the latter situated in the left channel near its lower end.

BEAVER BAR

is a uniform shoal, caused by too great width of water-way. It was contracted in 1873 by a wing-dam, extending from the right bank, 270 feet long. The benefit arising from the dam lasted until 1873, when gradual shoaling made scraping necessary.

LONE-TREE BAR

is similar in general character to the bar at Buena Vista, which will be described in detail farther on, and was treated in the same manner with equally unsatisfactory results, so far as permanent benefit is concerned. Scraping seems to be the only improvement which can be made at moderate cost on these two bars, the worst on the river.

M'CLOSKEY'S CHUTE.

Here the river at low-water was divided by a gravel island, the channel on the left having been the one used previous to 1877, when, the volume inclining to leave this channel and flow along the right shore, it was closed at its head by a dam, in which a low place was left to act as a waste-weir until the new channel should have cut out sufficiently to carry the entire low-water volume. Since building the dam the depth through the new channel has been ample; but the sluice, encountering at its foot a layer of concreted gravel too hard to be easily eroded, produces a crooked and shifting boat-channel, which, however, may be straightened by raking the hard-pan after it shall have been broken up by blasting. This will be tried the present year.

EOLA BAR.

The river here is 900 feet wide, a width sufficient to cause a shoal even without the disturbance of the current produced by the entrance, at a right angle, of the Rickreall, a stream which at high stages carries a large volume of water. A dam, built from the point of the gravel spit, near the left shore towards the crest of the bar, gave the desired depth.

ROCKY RAPID

is due to a ledge of rock cropping out from the right bank near low-water mark, extending half way across the river under water, with a number of bowlders scattered over its surface in the boat channel. These were broken up by blasting, and their fragments used to build a rough training wall near the right bank, since which there has been no trouble.

HUMPHREYS' RAPID.

Here there are two channels. That on the east is practically closed at its head by a gravel-bar; the other is obstructed by a dangerous ledge of rock near its lower end. In the year 1873 a dam, 300 feet long, was built from the head of the island which separates the two channels, extending up stream into the west channel, in the expectation of collecting the greater portion of the volume of the river into the east channel, without, however, producing the desired result. Accordingly, in 1876, the west portions of the ledge at the foot of the west channel were removed by blasting, greatly improving the passage. More work is still needed here.

LONG CROSSING BAR.

This bar is due to the excessive width of the river, which here is 700 feet. The boat channel lay close under the left bank, very narrow and crooked. Across this a dam was built, the effect of which was to force the current into the middle of the river, and scour out a good channel.

BUENA VISTA BAR.

The river is here 800 feet wide. About a mile above the bar a gravel spit makes out from the east shore, dividing the stream into two channels of about equal width; one, that on the east, practically closed at its head during low-water; the other, deep and rapid, flows along the base of a cliff of hard shale 150 feet high, until it reaches the foot of the spit, where it turns sharply to the right, and, spreading out in the shape of a fan, flows into the east channel, dropping 2 feet in a distance of 300. This is the bar. The plan adopted for its improvement was to run a dam from the end of the spit towards the west shore, making a sharp angle with the current to sluice out the gravel along the foot of the cliff. It was eminently successful, making a good channel within a few days after completion; but the benefit was only temporary, a bar similar to the first forming 500 feet below before the succeeding low-water stage. The dam was extended to the new bar, only to drive it several hundred feet below. Deep water being still distant nearly 1,000 feet below, and Luckiamute Bar, 1½ miles above, having already suffered from the increase of water-way over Buena Vista Bar, it was decided to depend on scraping at the latter, removing only so much of the crest of the bar as might be necessary to give passage to steamboats. This plan was carried out in the summer of 1879, with satisfactory results.

THE UPPER AND LOWER FICKELS BARS

resemble the bar at Long Crossing so closely as not to require a special description, and were improved in the same manner, with equally good results. Black Dog Slough is an arm of the river 150 feet wide, making out from the main stream above Lower Fickels Bar, abstracting a large volume of water. It was closed by a dam across its head.

PINE TREE BAR.

The river at this point is 480 feet wide at low-water. The right bank is 15 feet high, formed of sandy soil overlying gravel 3 feet thick, under which there is hard-pan. The left shore is a gravel flat, sloping back at a low angle for 200 feet. The rapid is one-half a mile long, the shoal water occurring at its head. Dams were built opposite the crest of the

bar on each side, converging toward the middle of the river, sluicing out a good channel.

BOWERS' BAR.

The trouble here is due to cement gravel extending across the river, 3 feet below low-water. The dam built in 1872 failed to cut out the hard-pan, but contracted the water-way so much as to cut through the spit of loose gravel 300 feet above, diverting a large volume of water from the boat channel. The gap was closed only to break out again; finally a new dam was built above the old one, and the latter torn out, since which there has been no trouble, except that the boat path is crooked.

HALF-MOON BEND.

Here there are two bars, distant apart one-third of a mile. At the lower bar the channel was very crooked, forming an S close under the left bank. A dam was built from the left shore 500 feet above the bend, sending the current across a gravel spit which made out from the right shore, cutting a straight channel with good depth.

At the upper bar the left bank is 15 feet high, composed of loose sand and gravel. A gravel spit forms the right shore at low-water. Dams were built from each shore, converging, deflecting the current from its path along the left bank which was rapidly caving, filling the channel below towards the center of the stream, where it cut out a new channel of sufficient depth.

STEWART'S BAR,

three miles below Corvallis, is the last obstruction on the low-water section. It is of recent appearance, and is probably due in great measure to the lowering of the bottom of the channel on Half-Moon Upper Bar, 1 mile below, since the dams were built there. The water being shoal for a long distance below the bar, there is no room for sluicing, and the required depth will have to be obtained by scraping from the axis of the desired channel towards the shores.

The improvement of the Upper Willamette was inaugurated in 1870, by surveys of Chitwood's, Matheney's, Lone Tree, Beaver, and Bowers' bars, and Humphreys' Rapid, made by Lieut. W. H. Heuer, Corps of Engineers, under the direction of Maj. R. S. Williamson, Corps of Engineers, who recommended scraping and the construction of a snag-boat and wing-dams for the ensuing year.

The first special appropriation for the Upper Willamette was made in 1871. Maj. H. M. Robert, Corps of Engineers, relieved Maj. R. S. Williamson from the charge of the improvement April 11, 1871.

1871-'72.

(Officer in charge, Maj. H. M. Robert, Corps of Engineers.)

Sum appropriated by act of March 3, 1871 .... $16,000 00

The operations during this fiscal year were as follows: A scraper of the pattern known as Long's was made, and used on Matheney's and Yamhill bars with good results, the former having since given no trouble, and the latter being greatly improved. A snag-boat, with hoisting apparatus worked by a hand capstan, was built at a cost of $4,857.56, and operated from the 6th to the 28th of November, 1871, when it was forced off by a rise in the river, having removed 39 snags aggregating 146 tons

weight, including all the most dangerous snags between Portland and Eola.

On May 1, 1872, a contract was made with Joseph Paquet for building 2,100 linear feet, more or less, of wing-dams, for $2.50 per foot. The sum expended during the fiscal year was $7,746.39.

1872–'73.

(Officer in charge, Maj. H. M. Robert, Corps of Engineers.)

Sum available, being the unexpended balance of last year's appropriation.. $8,253 61

In the fall of 1872 the scraper was used to advantage on Gibson's Bar, attached to the snag-boat, which was floated down over the bar and drawn up again with the capstan. Under the contract made the previous year dams were built at—

	Feet.
Bowers' Bar	359
Humphreys' Rapid	308
Lone Tree Bar	358
Beaver Bar	270
Union Bar	275
Yamhill Bar	430
Total	2,000

Two hundred and twenty-two large snags were removed by the snag-boat, principally from Eola Slough, Matheney's Bar, Biterman's Bend, Gervais Slough, Gibson's Bar, Fairfield, Big Slough, Carey's Bend, and Ash Island. The officer in charge recommended for the snag-boat a small donkey engine and boiler to work the hoisting tackle, and steam motive power as well; also, construction of wing-dams at points thereafter to be determined.

The sum expended during the year was $8,241.40.

1873–'74.

(Maj. H. M. Robert was relieved October 22, 1873, by Maj. N. Michler, Corps of Engineers.)

Sum appropriated by act of March 3, 1873.............................. $3,000 00

During the working season 280 snags were removed, giant powder being used to loosen those deeply imbedded in the bottom. Buoys were placed to mark the channel through the narrows at Rock Island, and on Tualatin rocks, a dangerous reef at the lower end of the narrows.

One thousand five hundred dollars and nine cents was expended during the year.

1874–'75.

(Officer in charge, Maj. N. Michler, Corps of Engineers.)

Sum appropriated by act of June 23, 1874.............................. $7,500 00

The work done during the year was the removal of over 900 snags between Portland and Harrisburg, 149 miles, and the opening of a new channel in the locality known as Devil's Graveyard, 10 miles above Harrisburg, by breaking up a raft 600 feet long, whereby the steamboat route was shortened by about 1 mile. This last was done by the crew of the snag-boat with the steamboat Ohio, hired for the purpose, it having been found impracticable to tow the snag-boat through the sharp

bends and bars bristling with snags, obstructing navigation for several miles below the raft. The new channel was named Ohio Chute.

Sum expended during the year, $7,500.

1875–'76.

(Maj. N. Michler was relieved December 28, 1875, by Maj. J. M. Wilson, Corps of Engineers.

Sum appropriated by act of March 3, 1875 .... $25,000 00

The snag-boat was supplied with a donkey engine and boiler to work the hoisting apparatus. Over 700 snags were removed between Davies' Prairie, below Harrisburg, and Oregon City; 12 cubic yards of rock were removed by blasting from Eola Slough, by the snag-boat, opening a channel through a ledge which crossed the slough 3 feet below low-water mark, and completing the diversion of the river through the slough saving one mile in distance.

In the fall of 1875, 1,530 feet of wing-dams were built at Lone Tree and Union bars under the contract of Peter & F. X. Paquet, dated September 9, 1875, for $1.80 per linear foot, and surveys were made ot the river from Eugene City to Ingram's Bend, 3 miles below Harrisburg, and from Albany to Salem; also of the most important bars below Salem, in all 66 miles.

Sum expended in 1875–'76, $16,961.75.

1876–'77.

(Officer in charge, Maj. J. M. Wilson, Corps of Engineers.)

Sum appropriated by act dated August 14, 1876 .... $20,000 00

Nine hundred and one snags were removed between Oregon City and the mouth of Long Tom Creek, an extent of 118 miles; 47 cubic yards of rock were excavated from Humphreys' Rapid, and 24¼ yards from Rocky Rapid, in all 71¼ yards.

Dams were built as follows:

	Linear feet.
At Half Moon Bend, upper bar	727
At Half Moon Bend, lower bar	189
At Bower's Bar	423
At Pine Tree Bar	583
At Upper Fickels Bar	553
At Black Dog Slough	331
At Lower Fickels Bar	190
At Cut-off above Buena Vista	230
At Buena Vista Bar	750
At Long Crossing Bar	756
Total	4,732

The hull of the snag-boat, having become unserviceable, was condemned and a new one with sides made of 6 by 8 inch timbers, laid on edge and fastened with screw-bolts, was built, and the machinery and house transferred. Centennial Chute, 12 miles above Corvallis, was cleared of drift by the snag-boat, turning the greater portion of the volume of the river into one of its minor channels known as Hague's Creek, which has since been used to the exclusion of the others as a low-water channel, maintaining a good depth and accumulating but little drift and being also shorter than either of the two others formerly used.

Amount expended during fiscal year, $13,796.47.

1877–'78.

(Under charge of Maj. J. M. Wilson, Corps of Engineers.)

No appropriations for river and harbor work having been made, the sum available for the operations of the present year was the unexpended balance from the last year, $14,246.54.

The snag-boat was employed between Oregon City and Peoria, 115 miles, removing during the working season 1,031 snags, aggregating 2,572 tons weight.

The following-named bars were surveyed, and new wing-dams built and old ones repaired when needed, under contract with Grant & Stone, dated February 26, 1877, for $1.90 per linear foot.

	Feet.
Black Dog Slough (carried away), rebuilt on a new line	210
Buena Vista Bar, repaired and lengthened	1,028
Long Crossing Bar, repaired	75
McCloskey's Chute, new dam	730½
Eola Bar, new dam	350
Lone Tree Bar, repaired and lengthened	747½
Union Bar, lengthened	162
Polalley Bar, new dam	408
Buena Vista Cut-off, new dam	129
Total	3,840

In July, 1877, navigation was impeded by drift and trees hanging over the bank of the new channel at McCloskey's Chute. The snag-boat being at the time engaged at Centennial Chute, 75 miles above, the steamboat City of Salem was hired to clear away the obstructions, which was done in two days, removing, with the aid of a powerful steam capstan, thirteen large trees and 3 stumps. While at work removing drift the stern wheel of the boat was kept revolving rapidly, increasing the sluice over the bar, cutting out large quantities of gravel and pebbles, too heavy to be moved by the ordinary force of the current.

Sum expended during the fiscal year, $14,120.29.

1878–'79.

(October 22, 1878, Maj. J. M. Wilson was relieved by Maj. G. L. Gillespie, Corps of Engineers.)

Sum appropriated by act of June 18, 1878 .... $20,000 00

During the year 753 snags were removed between Oregon City and Centennial Chute. Booneville Chute was cleared of drift as far as Booneville Landing, an important shipping point 6 miles above Corvallis.

August 20, 1878, a contract was entered into with Joseph Paquet for excavating 272 cubic yards of rock, more or less, from the vicinity of Rock Island, for $8.90 per yard. The work was finished October 15, 282.16 cubic yards having been removed, straightening the channel and cutting away dangerous rocks, which had caused more than one disaster.

In the spring of 1879 motive power was added to the snag-boat, making her independent of towing and increasing her efficiency generally, and a new house, pilot-house, &c., built on deck, the whole costing $5,907.01.

Raking was tried on the bar, at the foot of McCloskey's Chute, but little impression being made, however, on the hard bottom.

The sum expended during this fiscal year was $17,724.74.

1879-'80.

(Officer in charge, Maj. G. L. Gillespie, Corps of Engineers.)

Sum appropriated by act of March 3, 1879 .... $12,000 00

Five hundred and forty-three snags were removed from the river between Oregon City and Buena Vista during the year. The bars at Buena Vista, McCloskey's Chute, Lone Tree, Beaver, and foot of Gervais' Prairie, were scraped with good results, increasing the ruling depth to 30 inches.

In the spring of 1880 the motive machinery of the snag-boat having been found too weak to drag the rake over bars composed of hard pan, the square stern, preventing backing readily, increasing the difficulty, larger cylinders were substituted for those in use, the after rake was raised, and the boat placed in general good condition at a cost of $1,907.

A contract made with Joseph Paquet September 25, 1879, for the removal of 500 cubic yards of rock from the vicinity of Rock Island, at $7.40 per yard, is in force. Work was begun last fall, but interrupted by high-water and suspended for the season.

Sum expended during the fiscal year, $8,028.35.

Up to the present date $97,126.34 has been expended on the improvement of the Upper Willamette. The results of the work done may be briefly given in the statement that whereas previous to 1875 navigation was practically, if not entirely, suspended above the mouth of the Yamhill, 40 miles from Portland, for three months yearly, during low-water, during the last two years there has been no time when it was not possible for steamboats to reach Corvallis with from 35 to 40 tons of freight, and return to Portland with 100 tons. The improvement is due in part to the systematic and persistent removal of drift, preventing accretions to the bars, but principally to the dams constructed. Of the seventeen bars where dams have been built fifteen have been so improved as to no longer cause serious delay, and several have been substantially removed, having 4 feet depth at lowest stages. At two only—Lone Tree and Buena Vista—has the benefit been only temporary, consequent upon their peculiar conformation, which has been described above. It is true that since 1875 boats of lighter draught than before have been used during low-water; but with even these, during the first two years succeeding their introduction, navigation above Yamhill Bar during low-water was very difficult; although it was never suspended when there was freight enough above that point to make the trip an object.

DISTANCES FROM PORTLAND.

To—	Miles.	To—	Miles.
Milwaukee	5½	Long Crossing Bar	87
Oswego	7½	Buena Vista	90
Oregon City	12	Luckiamute Bar	92
Rock Island	16	Mouth of Santiane	93½
Polally Bar	18	Lower Fickels Bar	95
Boone's Ferry	25	Upper Fickels Bar	96
Butteville	29	Springhill	97
Champoeg	32½	Pine Tree Bar	100
Ash Island	37½	Albany	103
Yamhill Bar	40½	Bower's Bar	107
Carey's Bend	43	Half Moon Bend	110
Candianis Landing	43½	Stewart's Bar	111
Union Bar }	50	Corvallis	114½
Coffee Slough }		Boonville	120
Fairfield	54	Turntable	125
Head of Gervais Slough	57	Centennial Chute	125
Matheney's Bar }	58	Peoria	129
Wheatland }		Monroe Landing	138½
Beaver Bar	59½	Ingram's Ferry	146
Lone Tree Bar	60	Harrisburg	149
McCloskey's Chute	62	Railroad Bridge	152
Lincoln	63½	Ohio Chute	156
Kaiser's Rapid	66½	Saw-mill Bend	161
Chitwood Bar	68	Moswell's Ferry }	163
Salem	70	Mouth of McKenzie }	
Eola	73	White's Rapid }	169
Rocky Rapid	76	Davis Chute }	
Independence	80	Skinner's Bar	170½
Humphreys' Rapid	84	Eugene City	172

M M 3.

IMPROVEMENT OF THE UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON TERRITORY.

At the beginning of the fiscal year the amount available for continuing this improvement was $23,306.82. A project for the application of this sum was submitted to the department, by letter dated 19th April, 1879, and on the 22d of August I received telegraphic authority to invite sealed proposals, by public advertisement, till September 23, for the removal of solid rock from the channel of the Upper Columbia River, at Umatilla rapids, and of Snake River at Monumental, Texas, Palouse, and Long Crossing rapids, aggregating 1,600 cubic yards, more or less, so as to give 6 feet at low stage.

The proposals were opened at the advertised date, and on the day following the contract was awarded by the department to George J. Ainsworth, of Portland, Oreg., the only bidder, at $18 per cubic yard.

The contract calls for the removal of 1,100 cubic yards of solid rock, from any of the points above noted, that may be elected by the United States engineer in charge, is dated September 25, and will expire October 15, 1880.

The price per yard is higher than that of the last contract, but as the points of work were widely separated, requiring many transfers of the plant, and the currents swifter than usual, the proposal was thought to be reasonable and just.

After careful investigation it became apparent that the steamboats of the upper river found more difficulty in navigating the Lower Snake River than the Columbia, and work was in consequence authorized to commence at

MONUMENTAL RAPIDS, SNAKE RIVER, 40 MILES ABOVE ITS MOUTH

The river is here 1,500 feet wide, and the rapid is formed by a rocky reef on the right bank 800 feet wide, which is prolonged from its lower end by a long gravel bar to the opposite shore. At low stage the reef is covered with water at an average depth of 22 inches.

The channel skirts the outer edge of the reef, and finally passes it at the lower end through a narrow depression 100 feet wide, leaving a large mass of the ledge on the south side, against which boats frequently strike, when descending at low stage. The fall is 15 inches approximately in a distance of 150 feet, and the surface velocity 12 miles per hour. The water pours with great turbulence through the narrow gorge between the reef and the shoal, and ascending boats are always compelled to "line over" with the capstan.

The plan for the improvement consisted in clearing out all the small lumps in the mid channel, and in leveling off the crest of the ledge on the south side to a depth of 4½ feet at low stage.

The passage of these rapids by ascending boats of the first class was formerly made in from two to four hours; it is expected that the projected improvement will reduce this time to less than half an hour.

A careful survey of the rapids, including a minute measurement of the obstructing rocks, was made by the assistant engineer in September, and a copy of the chart accompanies this report.

The contractor reached the site of the improvement with his plant early in October, only a few days before the navigation of the river was suspended by low-water.

By the 20th of November the contractor had greatly reduced the crest of the main ledge and cleared away several of the smaller ones, making a comparatively good channel 200 feet wide, with an average depth of 4 feet.

As navigation of this part of the river had been suspended for over a month, and the river boats could reach the mouth of the Snake only with great difficulty, the contractor was permitted to discontinue work at Monumental Rapids and to transfer his plant to Homely Rapids in the Columbia River, near the mouth of the Snake.

HOMELY RAPIDS, COLUMBIA RIVER.

These rapids were reached on the 2d December. At this point there is a long, wide shoal bar, but the principal obstruction consisted of five large bowlders closely grouped in the center of an otherwise practicable channel at low-water.

The Northern Pacific Railroad had commenced the building of a part of its western division extending from Ainsworth, a newly-located town at the forks of the Columbia and Snake, eastward to Lake Pend d'Oreille, and it was highly important that material and supplies should be readily transported by water from Wallula to Ainsworth. The only obstacle to be overcome was the difficult passage at Homely Rapids.

The contractor worked with great vigor and energy, and by the 19th December, when he was compelled to withdraw on account of the floating ice, he had succeeded in clearing out the group of five bowlders aggregating 156 cubic yards. About 300 feet above this group there are a great many other bowlders of smaller size which should also be removed, but they are so situated that boats can avoid them by careful pilotage, and it has been thought best to defer working upon them until more dangerous obstructions at other points of the rivers shall have been removed.

UMATILLA RAPIDS, 20 MILES BELOW WALLULA, COLUMBIA RIVER.

The water in the Upper Columbia was very low throughout the autumn and winter, and the Umatilla Rapids could seldom be passed either way without injury to the boats. In September two boats were lying stranded upon the rocks at the head of the channel at the same time. The improved government channel on the left bank has more water and is straighter than the old channel, but the trouble in using it arises from the swiftness of the current, the greater fall in the same distance, and the narrowness of the entrance on the upper side, which causes the descending boats to be occasionally thrown against its rocky walls when endeavoring to make it. This trouble is so magnified at a very low stage that some of the pilots will not use the channel at all.

A careful survey was made of the river at the entrance to the government channel in October preparatory to the removal of a large rock in the upper pool common to the two channels and to the widening of the upper entrance to the government channel by blasting away the left bank.

The contractor commenced the execution of this improvement on the 15th of November and worked uninterruptedly till the 19th of December, when the flow of ice compelled the withdrawal of the plant. No important results were obtained, as the current was very swift and the winds so bitterly cold that the drillers could endure the exposure only by frequent reliefs.

These rapids are 2 miles long, and are divided into three separate rapids, connected by short pools. The fall from the head to the foot is 18 feet, and the surface velocity varies with the stage from 4 to 12 miles per hour. A steamboat of the first class usually makes the passage at low-water in thirty or forty minutes.

Work has not been resumed since its suspension in December.

In March I made an examination of the rapids in the Upper Columbia as far up as Wallula in company with Lieut. C. F. Powell, Corps of Engineers. The water was at low stage, and I had an excellent opportunity of judging of the dangerous character of the rapids, the extent to which they had been improved by the government, and the skill and daring required of the pilots to make the navigation a practicable one.

By act approved June 14, 1880, the sum of $15,000 was appropriated for continuing the improvement. It is expected that this sum will be applied in an attempt to open a navigable channel 100 feet wide with 6 feet at low stage through Texas Rapid, Snake River, 67 miles from its mouth.

The rapid, which has never been improved, is about 1 mile long, and the fall in this distance is 15 or more feet. The surface velocity varies from 9 to 12 feet at low stage, and the whole river at this point is so filled with dangerous rocks, visible at low stage, that there is practically no defined channel through the rapids. It has been estimated that 700 cubic yards of solid rock will be required to be removed.

From Texas Rapids to Lewiston no obstacles are met with which good pilotage cannot overcome.

The next most important point in the Snake River, which demands improvement, is at Pelouse Rapid, 10 miles below Texas. The channel is very narrow, and is broken up by five large dangerous rocks, not easily avoided, and the current is exceedingly swift. The five rocks, aggregating 300 cubic yards, should be removed. I would also recommend that a few rocks, aggregating not more than 200 cubic yards, at False Pelouse, be removed, and the improvements commenced at Monumental and Umatilla Rapids be continued.

In compliance with the act of June 23, 1866, I respectfully state that the amounts appropriated for this work, from act of June 10, 1872, to act of March 3, 1879, both inclusive, were	$160,000 00
By act approved June 14, 1880	15,000 00
Making the total appropriation to date	175,000 00

Of this amount $143,494.82 have been expended to date.

The Oregon Railway and Navigation Company, successor to the Oregon Steam Navigation Company, is building, and will have in readiness for operation by November 1, 1880, a standard gauge railroad along the left bank of the Columbia River, from Wallula to the Dalles, and is preparing to extend the same to Portland, Oreg. It proposes likewise to build, as feeders to the main line, a railroad from the mouth of the Pelouse to Union Flat, about 35 miles, and from Walla Walla, through Waitsburg, to the head of Pataka Valley, with a branch down the Incannon to the Snake, at Grange City (Old Fort Taylor).

These constructions will materially aid in developing all the available lands in Eastern Oregon and Washington Territory, will make the large railroad corporation, to a certain degree, independent of the water-courses, and will enable the distant farmers to get their crops, with certainty, to market, when navigation is suspended in Snake River by low-water or by ice. They will not, however, diminish the importance of the rivers, which should be improved more and more, each year, by the removal of their isolated rocks and reefs, so as to prolong the duration of low-water navigation, and thereby keep pace with the growth and development of this rich agricultural country, which has just started in its career of development.

These rivers are in the collection district of the Willamette. Portland, Oreg., is the nearest port of entry. The nearest light-houses and works of defense are at the mouth of the Columbia River, but troops garrison the posts of Walla Walla, in the interior, about 32 miles from Wallula, on the Columbia; of Fort Lapwai, on Lapwai Creek, 12 miles from Lewiston; of Fort Cœur d'Alene, on the lake of that name, 100 miles nearly due north of Lewiston; of Fort Colville, 125 miles northwest from Cœur d'Alene, south of the Big Bend of the Columbia River, and at Fort Chelan, near the Columbia River, 150 miles above the mouth of the Snake.

The amount of revenue collected at Portland during the eleven months ending June 1, 1880, was	$97,441 82
Value of imports	264,633 70
And that of exports	4,081,188 40
The number of vessels entering was	191
With an aggregate tonnage of	232,189
The number of vessels clearing was	190
With an aggregate tonnage of	237,193

It is impossible to state the amount of commerce that will be benefited by the continuance of this improvement, but it will be very large, and will comprise all the different elements of commercial wealth which characterize a rich and extensive agricultural and grazing country.

Abstracts of proposals and contract, a statement of funds, and a chart of Monumental Rapids are transmitted herewith. It is requested that the chart be printed.

Money statement.

July 1, 1879, amount available	$23,306 82	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$38,306 82
July 1, 1880, amount expended during fiscal year	6,351 64	
July 1, 1880, outstanding liabilities	450 00	
		6,801 64
July 1, 1880, amount available		31,505 18
Amount (estimated) required for completion of existing project		77,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 00

Abstract of proposals for the removal of rock from the channels of the Upper Columbia and Snake Rivers, opened by Maj. G. L. Gillespie, Corps of Engineers, September 23, 1879.

Number.	Name and residence of bidder.	1,600 cubic yards of rock, more or less (per cubic yard.)	Remarks.
1	George J. Ainsworth, Portland, Oreg	$18 00	Contract awarded.

Abstract of contract for improving the Upper Columbia and Snake Rivers, in force during the fiscal year ending June 30, 1880.

Number.	Name and residence of contractor.	Date of contract.	Subject of contract.	Price per cubic yard.	Remarks.
1	George J. Ainsworth, Portland, Oreg.	Sept. 25, 1879	Removal of rock.	$18 00	Contract expires October 15, 1880.

CONDENSED HISTORY OF THE IMPROVEMENT OF THE UPPER COLUMBIA AND SNAKE RIVERS.

The Columbia River rises in British Columbia, on the western slope of the Rocky Mountains, in about 50° north latitude and 39° longitude west from Washington. Its initial course is northwesterly for 150 miles; then southerly, through eastern Washington, for 300 miles, receiving the Lewis and Clarke Fork and Spokane River from Northern Idaho, the Okinagan from British Columbia, the Yakinna from the Cascade Range, and the Snake from Middle and Southern Idaho and Nevada; and from the mouth of the Snake westerly for 250 miles to its entrance into the Pacific Ocean, receiving from Oregon the Umatilla, John Day, Deschuttes, and Williamette rivers, besides numerous smaller tributaries. Its entire length is estimated at 1,400 miles, of which 733 are navigable.

Above the mouth of the Williamette, 100 miles from the sea, it is generally rocky and rapid, at three points especially, viz: the Cascades, the Dalles, and Priests' Rapids. These conditions are intensified to the extent of opposing complete barriers to navigation; dividing the river into three navigable reaches, known as the Lower, Middle, and Upper Columbia, to which last should be added the Snake River from its mouth to Lewiston, Idaho, navigation being continuous from the head of the Dalles to Lewiston, and this section being known officially as the "Upper Columbia and Snake."

Between the mouth of Snake River and Priests' Rapids steamboats run only occasionally. The canal and locks now building at the Cascades will, when completed, connect the steamboat navigation of the Middle and Lower Columbia. These two sections are unobstructed.

The obstructions on the Upper Columbia below Snake River are:

Five-mile Rapid, 5 miles above Celilo (the head of the Dallas.)
John Day Rapids, lower, middle, and upper, 15 to 18 miles above Celilo.
Indian Rapid, 21 miles above Celilo.
Squally Hook Rapid, 24 miles above Celilo.

Rock Creek Rapid, 28 miles above Celilo.
Owyhee Rapid, 38 miles above Celilo.
Canoe Encampment Rapid, 60 miles above Celilo.
Devil's Bend Rapid, 80 miles above Celilo.
Umatilla Rapids, lower, middle, and upper, 85 to 88 miles above Celilo.
Mill Rock Rapid, 91 miles above Celilo.
Homely Rapid, 110 miles above Celilo.

And on Snake River below Lewiston:

Five-mile Rapid, 5 miles above the mouth of the Snake.
Three Islands Rapid, 10 miles above the mouth of the Snake.
Fish-Hook Rapid, 16 miles above the mouth of the Snake.
Long Crossing Bar Rapid, 31 miles above the mouth of the Snake.
Pine Tree Rapid, 33 miles above the mouth of the Snake.
Monumental Rapid, 41 miles above the mouth of the Snake.
False Palouse Rapid, 53 miles above the mouth of the Snake.
Palouse Rapid, 58 miles above the mouth of the Snake.
Texas Rapid, 68 miles above the mouth of the Snake.
Steptoe Rapid, 135 miles above the mouth of the Snake.

With the exception of the last named, which is of gravel, the above are all rocky bars and resemble each other so nearly in their principal features as not to require to be separately described. Generally they are characterized by narrow, crooked channels winding through beds of rock in position, with occasional bowlders and ledges reducing the generally ample depth to 2 or 3 feet.

Before any improvements were made nearly all of them were extremely dangerous, and some quite impassable at low-water. Since improvement the river affords, between Celilo and Lewiston, a fair low-water channel from 60 to 150 feet wide, and from 4½ to 5½ deep at low-water through the rapids and bars.

Steamboat navigation above the Cascades was opened in 1852 by three small steamboats, the James P. Flint, Cosmopolite, and Allen, of 20, 25, and 15 tons burden, respectively, running between the Cascades and the Dalles. In 1865 the *Forty-nine*, 125 tons, was built at Colville, and operated for 200 miles above that point; and in the same year the *Shoshone*, 150 tons, was built at Fort Boise, Idaho, to run from Old's Ferry, on Snake River, up the Owyhee.

The *Col. Wright*, 302 tons, built at Deschuttes, 1858, was the first steamboat to run between Celilo and Lewiston.

The names, dimensions, and dates of construction of the other boats heretofore and at the present time operated on this section, will be found on the list appended to the history of the improvement of the Lower Williamette and Columbia herewith submitted. The number at present in use is seven, aggregating 4,605 tons.

The first step toward the improvement of the Upper Columbia was taken in 1867. In September of this year examinations were made by Lieut. W. H. Heuer, Corps of Engineers, under the direction of Maj. R. S. Williamson, Corps of Engineers, of John Day, Indian Squally Hook, and Umatilla Rapids for the purpose of ascertaining the character, extent, and cost of removal of obstructions to navigation. The cost of obtaining a depth of 7 feet at these four points, and in addition at Rock Creek and Homely Rapids, was estimated at $132,328, and an appropriation asked for.

The examination on which this estimate was based cost $9,049.95.

1868–'69.

(Officer in charge, Maj. R. S. Williamson, Corps of Engineers.)

Amount available July 1, 1868, being unexpended balance of the original allotment of $25,000	$10,165 16
Sum expended during fiscal year	4,478 62

Surveys of Rock Creek and Homely Rapids and experiments in blasting rock at John Day Rapid were made by Lieutenant Heuer in the fall of 1868. Although the experiments were made under the most unfavorable conditions, their result, so far as giving the probable average cost of this class of work is concerned, has been verified by subsequent experience.

Nothing further was done until the fall of 1871, when the officer in charge, Maj. H. M. Robert, Corps of Engineers, who relieved Maj. R. S. Williamson April 11 of that year, ascended to Wallula, 6 miles below the mouth of the Snake, in one of the Oregon Steam Navigation Company's steamboats, examining the rapids, and recommended an appropriation for the improvement of John Day, Devil's Bend, and Umatilla Rapids.

1872–'73.

(Officer in charge, Maj. H. M. Robert, Corps of Engineers.)

Amount available July 1, 1872	$50,000 00
Expended during fiscal year	21,785 67

A contract was made in October, 1872, with J. B. Montgomery for removing rocks from John Day, Devil's Bend, and Umatilla Rapids, at $50 per yard for the first 200 yards and $25 for each additional yard.

Work was begun about the middle of November and carried on with interruptions during December and January from running ice until March 1, when the river began to rise. The whole of John Day rock down to 7 feet below mean low-water, about 1,000 cubic yards, was removed, and 213½ yards from Umatilla Rapid, where the rocks marked W, X, Y, and Z, were removed.

Work was begun on rock E, but suspended on account of high-water.

The work contracted for was not finished, and the contractor was allowed until April 30, 1874, to complete his work.

The officer in charge recommended an appropriation for the improvement of Homely Rapid, at the mouth of the Snake, and other points not specified.

1873–'74.

(Officers in charge—until October 22, 1873, Maj. H. M. Robert; after that date, Maj. N. Michler, Corps of Engineers.)

Amount available (balance from last year's appropriation)	$28,214 33
Amount expended during the year	28,085 00

Four hundred and sixty-five cubic yards of rock were excavated from Devil's Bend and Umatilla Rapids. At the first-named point a channel 100 feet wide and 600 feet long was opened to a depth of 5½ feet below low-water mark by removing all bowlders and rocks within these limits.

Early in January, 1874, work was resumed on the Lower Umatilla Rapid, and by the end of the month the rocks C, C′, C″, and D had been removed, and the work at Lower Umatilla Rapid accepted as complete.

The plant was then taken to the upper rapid, and work resumed in the high-water channel there, and continued until February 25, when the funds being exhausted the work done was accepted as far as completed.

1874–'75.

(Officer in charge, Maj. N. Michler, Corps of Engineers.)

Amount appropriated June 23, 1874	$20,000 00
Expended during fiscal year 1874	19,411 34

Operations were confined to Umatilla and Squally Hook Rapids, removing nine rocks, three aggregating 158.29 cubic yards, from the former, and six, aggregating 192.06 yards, from the latter point. Surveys were made of the Cascades and the Dalles Rapids, and a project for the improvement of the first named submitted, to consist of a canal and locks; that for the Dalles being deferred until a more minute survey than was possible with the amount then available should be made.

1875–'76.

(Officers in charge—to December 28, 1875, Maj. N. Michler; after that date, Maj. J. M. Wilson, Corps of Engineers.)

Amount appropriated by act of March 3, 1875	$35,000 00
Expended during the fiscal year	19,637 41

On the 29th of October a contract was made with Grant & Stone for removing rock from Homely, Rock Creek, Owyhee, and Umatilla Rapids, at $36 per yard. Work was begun at Homley Rapid about November 18 and prosecuted, with interruptions from drift ice and muddy water, until February 6, 1876, when it was completed; one reef and eight separate rocks, 118.36 cubic yards in all, having been removed. The plant was then shifted to Umatilla Rapids where work was pushed with energy, removing five rocks containing 367.49 yards by March 1, when an explosion of giant powder occurred, killing thirteen men and wounding others, and wrecking the contractors' scow.

Work was begun at Squally Hook Rapid, but suspended in consequence of an accident to the plant which could not be repaired until the water rose, and was not resumed during this season; 485.85 yards in all were removed during the fiscal year.

1876–'77.

(Officer in charge, Maj. J. M. Wilson, Corps of Engineers.)

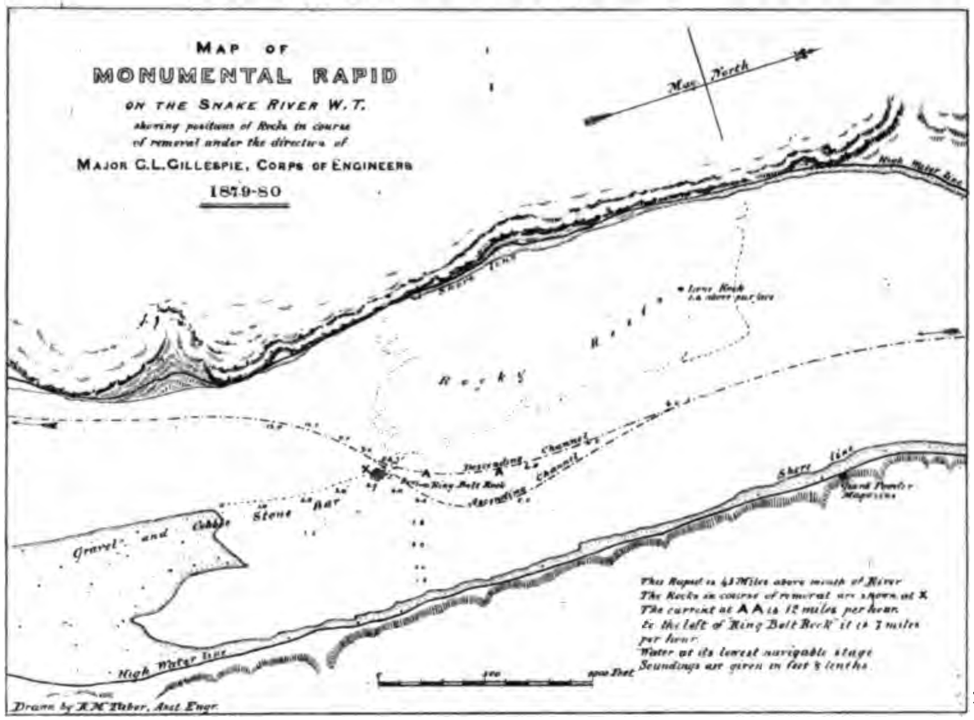
Amount appropriated by act of August 14, 1876	$15,000 01
Amount expended during fiscal year 1876	25,257 00

The operations of the year consisted in removing from the channel at—

	Cubic yards of solid rock.
Squally Hook Rapid	150.06
Owyhee Rapid	67.57
Umatilla Rapid	50.00
Pine Tree (Snake River)	477.51
Total	745.14

The work at Umatilla Upper Rapid cost $31 per cubic yard, and that at Pine Tree Rapid $24.75; and was done under contracts dated August 2, 1876, and November 11 of the same year by J. B. Montgomery. The work at Squally Hook was done under contract dated November 20, 1876, and that at Owyhee Rapid under contract dated October 29, 1875, by Grant & Stone.

Operations during the winter were greatly impeded by floating ice, so much so that it was found impossible to complete the work contracted with J. B. Montgomery within the time specified, and his contract was accordingly extended until February 28, 1878. In spite of the difficulties under which the work was done the amount accomplished was large, comprising the removal of twenty dangerous rocks from Pine Tree Rapids, and two from Owyhee and Squally Hock Rapids, greatly improving the channel at these points.



U.S. ENGINEER OFFICE PORTLAND, OREGON
To accompany annual Report June 30th 1880
G. L. Gillespie
Major of Engineers, Brt. Lt. Col. U.S.A.

The total amount of work done, including materials delivered by the contractors under their contract, is tabulated as follows:

Material removed:

Earth	cubic yards..	28,944
Loose rock	do	12,102
Solid rock	do	26,640
Rubble blocks delivered not hammered	do	549
Second-class ashlar stone, dressed ready for laying, &c	do	585
Ashlar blocks delivered, not dressed	do	264
Iron pipe	pounds..	186,292

The work done by hired labor since the abrogation of the contract is as follows:

Bowlders excavated above surface level, not measured.
Material excavated below surface level, 35,080 cubic yards.
Second class ashlar, not laid, 273 cubic yards.
Ashlar blocks not dressed, not measured.

The annual rise in the Columbia commenced in May, but the weather remained so cool that it was believed in the beginning that the freshet would not reach the high stage of previous years. After the middle of June the warm weather caused a rapid melting of the great snow accumulations at the sources of the Columbia and Snake Rivers, and the lower river began to rise so rapidly as to threaten a higher stage than that which occasioned such a destruction to property in 1876. At the close of the year the water had risen at gauge No. 1 to 137.9 feet, or 1.5 feet below the highest stage of 1876, with a tendency to rise still higher. The crest of the embankment on the river side, designed to protect the canal at the high stage, was below the highest water level when the river began to rise, but by the industrious efforts of Lieutenant Powell, in local charge, the work was pushed so vigorously, night and day, that the crest was always kept in advance of the rising waters. The green state of the work and the immense power of the mighty waters made us fear that a crevasse might at any time be made through the embankment into the canal. Fortunately the strong profile of the embankment and the massive character of the materials, and the excellent way in which they were arranged, proved amply sufficient to resist the great pressures of the river in its flood.

The appropriation of $100,000, act June 14, 1880, will be applied in continuing the excavation of the lock-pits and possibly in commencing the masonry of the locks, and in enlarging the protective embankment. A building for the quartering of the increased force to be employed the coming year will also be erected under the authority of the department of May 28, 1880.

I invite the attention of the department to the accompanying report of Lieut. C. F. Powell, Corps of Engineers, in local charge, which gives a full history of the work under his charge during the year. I am under the highest obligation to this officer for his devoted and zealous assistance at all times, and especially do I commend his untiring personal efforts at the time the freshet threatened to do so much damage to the improvement. His administration and superintendence of the work are characterized by the highest order of intelligence, industry, and economy.

The following statistics required by act of June 23, 1866, are respectfully submitted. The appropriations for this work have been as follows:

From act of August 14, 1876, to act of March 3, 1879, both inclusive	$340,000 00
Act of June 14, 1880	100,000 00
Total	440,000 00

The estimated cost of the project is $1,753,867; of this amount $500,000 can be profitably expended during the next fiscal year in continuing the excavation of the canal prism, the building of the protective embankment, and in building the masonry of the locks.

The condition of the work at the close of the fiscal year is given on the accompanying progress-sheet. There is also transmitted a chart of water curves at the several gauges, both of which I respectfully request be printed to accompany the printed report.

The Cascades of the Columbia River are in the collection district of the Willamette. The nearest port of entry is Portland, Oreg., 65 miles distant; the nearest light-houses and works of defense are at the mouth of the Columbia, about 160 miles distant.

Amount of revenue collected at the port of Portland, Oreg., from July 1, 1879, to May 31, 1880	$97,441 82
Value of imports from foreign countries	264,633 70
Value of exports to foreign countries	4,081,188 40
Number of foreign vessels:	
Entered from foreign countries, 58; tonnage	54,366
Entered coastwise, 13; tonnage	11,458
Number of American vessels:	
Entered from foreign countries, 6; tonnage	3,456
Number of foreign vessels cleared to foreign countries, 73; tonnage	66,856
Number of American vessels cleared to foreign countries, 30; tonnage	20,912
Number of coastwise entrances, 114; tonnage	162,909
Number of coastwise clearances, 87; tonnage	149,425

By the construction of the Cascades Canal, free navigation of the Columbia River will be opened to the Dalles, a distance of 230 miles approximately above its mouth.

No official statement of the tonnage carried by the steamboats, both ways, on the upper river during the year has been obtainable, but it is believed that it has been in excess of 100,000 tons. It is impossible to state the extent to which commerce will be benefited by the improvement. Some persons of information and intelligence assert that the improvement is not needed at all, and that the money expended in it should be applied elsewhere, whilst others say with equal earnestness that the improvement will be an inestimable boon to the entire country east of the Cascade Range of mountains. The construction of railroads along the banks of the river may lower the present importance of the locks, but it is believed that as the country develops more and more the advantages of an uninterrupted navigation to the Dalles will be recognized by every one interested in the welfare of the State.

Abstract of contracts, money statement, river curves, and chart showing work done during the year are transmitted herewith.

Money statement.

July 1, 1879, amount available	$284,743 43	
Amount appropriated by act of June 14, 1880	100,000 00	
		$384,743 43
July 1, 1880, amount expended during fiscal year		207,626 83
July 1, 1880, amount available		177,116 60
Amount (estimated) required for completion of existing project		1,324,337 70
Amount that can be profitably expended in fiscal year ending June 30, 1882		500,000 00

rammed. The adjoining widths for 5 to 10 feet were generally made by wagons or barrows; and of the main embankment the widths next to the slopes were made of stone, heavy material, and gravel, dumped from cars. On the outer slope the stone was barred into place or pitched by hand. The embankment across the canal line and slough was made by wagons and stone sleds.

When the rising river reached the ordinary flood line the embankment would have held only for a rise of 2 to 3 feet. By strenuous efforts it has been kept ahead of the flood. The part across the canal line on the slough, 438 feet in length, is now 0.5 foot above highest water and fairly completed. Of the main embankment, 1,322 feet long, the outer width only of 4 to 8 feet is up to grade. As was expected, this part broke the force of the current, but allowed easy seepage. The depression between it and the trench portion became rapidly filled with water, which was divided into pools and stepped down according to the height of the plank walls and river opposite by transverse dams of sand bags, with openings at the middle. The water from the lowest pool escaped through the heavy riprap which terminates the lower end of the embankment. When time did not suffice to fill with puddle, the seams of the planks were calked with rope strands. By hard work, careful precautions, and constant watchfulness, we have been able to keep ahead of the river.

The employés worked cheerfully at night and over time, and evinced as much interest in the struggle for supremacy against the mighty Columbia as those directly in charge. The valuable service given by Assistant Engineer Breckinridge, who has been acting as overseer, is acknowledged.

Late velocity measurements at each 100 feet along the main embankment gave results from 4 to 12 feet from the water-line of 3.6 to 11.4 miles per hour, and about 25 feet from the water-line of 8.5 and 16.7 miles per hour.

The enlargement of the high-water channel along the embankment and its prolongation was to partly compensate for the occupation of water-way by the canal. The work consisted of leveling down conglomerate masses and bowlders, and cutting away the face of a ridge below the embankment, where the river is choked so that the extreme rise has been some 13 feet more than at the head of the canal.

The compensation of water-way tends to prevent the raising of the flood line above, which the canal construction would cause.

A progress profile and a sheet of water-level curves are transmitted herewith.

A table appended gives amounts of excavation made and material supplied. Work exterior to the canal-cut proper is not shown on the progress sheet or given in the table. Some little work in deepening the cut is also omitted from the want of measurements, which could not have been conveniently made.

The total and progress depths on the profile are proportionate to the total and progress areas of cross-section, based on a bottom width of canal prism of 50 feet, with slopes of 1 : 1 and a lock width of 70 feet with slopes of the pits of 1 : 0.5 horizontal.

During the year a cement testing and pattern house, a small warehouse at the head of the landing pier, a wagon-shed, a tool-house, and a blacksmith shop have been built; small repairs made to the mess-house and lodging house, and an addition for a drying room attached to the latter.

The field work of the survey below the locks to the old Lower Cascade Landing, which was called for by he Board of Engineers for the Pacific Coast last fall has been completed; the mapping on four sheets on a scale of 1 inch to 50 feet is about one-third made. The survey was based on a triangulation covering both banks and Bradford's Island, and a level circuit with crossings of the river at both limits of the survey. Topography was run with the stadia, 6,500 soundings were made, 400 surface-velocity floats were observed at 12 selected places of greatest current, and distributed through different stages of river. Mr. J. A. Gillespie was in charge of the hydrographic party. The courage and good judgment displayed by him in sounding in dangerous water is worthy of commendation.

The history of some attempts this year to navigate the river above the Lower Cascades is valuable from their bearing on the proposed improvement.

The government scow Snowflake, 80 by 20 feet, was sailed with ease from the Lower Cascades under an ordinary wind to the foot of the proposed breakwater on April 2, when the river at gauge No. 2, foot of lock location, was 5 feet above low-water. The scow was lined through Big Eddy Rapids during a calm on April 13, when gauge No. 2 read 13 feet above low-water. She was sailed directly into the lock pits on April 26, when gauge No. 2 read 14.5 feet above low-water.

The Columbia River boat Lurline, on an experimental trip steamed without any difficulty to Ruckel's Landing on May 1. She made no attempt to ascend further. Ruckel's is 2,900 feet below the Middle Block-house Rapid, and 4,700 feet below the foot of the proposed breakwater. Gauge No. 2 on May 1 read 21 feet above low-water.

The steamer McCully, built for the Willamette River, in an attempt to reach the Upper Cascades on June 1, got to the Middle Block-house Eddy with some trouble,

but utterly failed to stem the rapid, and in fact could not hold her own in the current. Gauge No. 2 on June 1 read 40 feet above low-water.

Very respectfully, your obedient servant,

CHAS. F. POWELL,
First Lieutenant, Engineers.

Maj. G. L. GILLESPIE,
Corps of Engineers.

Work done by—	Excavation.		Total material removed.	Second-class ashler, delivered, not laid.	Ashler blocks, delivered, not dressed.	Rubble blocks, delivered, not hammered.	Cast iron filling pipe.
	Bowlders above surface levels.	Material below surface levels.					
	Cub. yds.	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Pounds.*
Contract	7,983	56,995	64,978	585	264	549	186,292
Contract deposit		2,708	2,708				
Hired labor	Not measured	34,170	34,170	273	Not measured		
Hired labor deposit		910	910				
Total	7 983	94,783	102,766	858	264	549	186,292

The last measurements were made—
From station 6 + 80 to station 14 inclusive, May 14, 1880.
From station 14 + 20 to station 19 inclusive, May 1, 1880.
From station 19 + 20 to station 21 + 20 inclusive, April 29, 1880.
From station 21 + 40 to station 22 + 80 inclusive, April 22, 1880.
From station 23 to station 24 inclusive, April 27, 1880.
From station 25 to station 29 inclusive, April 12, 1880.
From station 29 + 20 to station 31 inclusive, March 25, 1880.
Cut stone to June 26, 1880.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., August 19, 1879.

GENERAL: The Board of Engineers for the Pacific coast has, in obedience to the telegraphic instructions of the Engineer Department, dated July 22, 1879, considered the points referring to the canal around the Cascades of the Columbia River, presented by Major Gillespie in his letter of August 6, a copy of which is appended, marked A. In this letter Major Gillespie recommends that operations at the locks be confined for the present to the excavation of the prism of the canal, leaving the masonry construction untouched, until the navigation of the river below the Cascades shall be improved, and that this improvement shall be at once undertaken by removing the reefs which lie in the river below the main rapids.

The Board spent four or five days in the study of the maps, profiles, and ground, and in conference with Major Gillespie and his assistant, Lieutenant Powell, of the Corps, and in this way endeavored to reach a knowledge of the general situation and prospects of this important work.

It will be remembered that in 1877 the Board considered the project for this work prepared by Maj. John M. Wilson, and recommended its adoption with certain modifications.

Since the date of this report, which was in September, 1877, the river has reached points at low-water at the foot of the breakwater, 2½ feet

below the low-water assumed in the preparation of the original project. This low-water stage is said to be the lowest that the river has reached in 10 years.

The department has also, since the date of the report of 1877, authorized an increase of width of chamber from 50 feet, as recommended by the Board, to 70 feet.

During the last high-water stage Lieutenant Powell made observations upon the velocities of the current at different points below the lower end of the breakwater, as proposed by Major Wilson and as adopted by the Board, and found these velocities to be as high as 17.4 miles an hour.

Gauges have also been established at different points along the line of the canal for a distance of 1.4 miles. These gauges have been read at different stages of the last high-water and have afforded the means of constructing a longitudinal profile of the river in its high stage, showing great variation in its slopes.

The preceding statement is an outline of existing information bearing upon the subject of the canal at the Cascades, additional to that which was before the Board when it drew up its report in 1877, and in the light of these facts, we now proceed to consider the suggestions of Major Gillespie.

The velocity observations already mentioned were made by Lieutenant Powell on the 16th, 17th, and 18th of June, 1879, when the river was slowly rising and still 12½ feet below the high-water mark of 1876.

Over a distance of 3,500 feet below the foot of the breakwater as now projected, the velocities necessarily to be encountered by a steamer endeavoring to reach the locks varied from 14.6 miles to 17.4 miles per hour.

On August 4, 1879, when the Board saw the current, the river was 25 feet below the high-water mark of 1876, and was slowly falling.

The velocity on this date was doubtless considerably less than it was at the date of Lieutenant Powell's observations. The Board is of the opinion, that reduced as the velocity was at the time of its visit, the current was yet too strong to be overcome by a steamer.

The river has, at times since March 31, been considerably higher than it was on August 4, but never lower, so that it is reasonable to assume that during four months in the present year, beginning with April, the velocity of the current in this part of the river has not been lower than it was on August 4. In other words, navigation of the river was, for this period of time, impracticable.

How much longer than four months, in the present year, the river has been and will be at this point, unnavigable, we cannot say with definiteness, but there can be no doubt that this period of compulsory disuse of the river may embrace half the year. In other terms, the locks under the present condition of affairs, although projected for high river, can be reached from below only at a low or medium stage.

At a low stage of the river the current below the breakwater, although rapid, being in one place as much as 8½ miles per hour, is practicable, and during this stage of water, which lasts about half the year, the breakwater can be reached from below and the locks used. In order, however, to make this low-water navigation below the breakwater reasonable instead of barely practicable, it seems to us that the reefs which form the two main rapids below the breakwater ought to be removed.

We are informed by the letter of Major Gillespie that no survey of these reefs has been made with the view of obtaining an estimate of the cost of their removal, but Major Gillespie estimates the quantity of rock

to be removed approximately, from the information in his possession, to be 50,000 cubic yards, in order to give 10 feet at low stage of the river.

The Board is of the opinion that such a survey and estimate ought to be made as soon as possible, to include the whole of the reefs, for the reason that there is some ground to hope that an extensive excavation of these reefs would not only improve the navigation of the river at the low stage, but also afford important relief in another and totally different respect, which we now proceed to notice.

The gauges established by Lieutenant Powell, and read during the high stage of the present year indicate, as will be seen by the longitudinal profile accompanying this report, marked B, that there is an engorgement of the river in its high stage near station 54.

By reference to the map prepared under direction of Maj. N. Michler, Corps of Engineers, October, 1874, a copy of which, it is supposed, is in the department, it will be seen that the first reef lies just below this station, and is probably the cause of the engorgement. If this reef be removed it must have the effect to lower the flood line along the breakwater and to lessen the height of this construction if it should be made to accommodate high-water navigation.

The removal of these reefs will also have some effect in lowering the low-water level at the foot of the locks, and in this connection the Board thinks with Major Gillespie it is indispensable that the improvements of the river should precede the building of the locks.

If the low-water at the foot of the locks be assumed on the data that we now have, and the locks be now built, it is quite possible and even probable that, when the reefs below are removed, and the low-water level at the foot of the canal lowered, the locks will fail to serve fully the purposes for which they have been projected.

We summarize these opinions as follows:

1st. That the medium and high-water navigation of the portion of the river just below the canal is, under present conditions, impracticable.

2d. That the low-water navigation of this portion of the river is, under present conditions, practicable, but not convenient, and not such as ought to exist in the approaches to a canal of the magnitude and importance which this must always be as the outlet of an extensive agricultural country.

3d. That the low-water navigation can be improved and ought to be improved by the excavation of the reefs which contract the low-water section.

4th. That the excavation of these reefs will, according to the extent of their removal, tend to lower the level of low-water at the foot of the breakwater, and also to equalize the high-water slopes and velocities.

5th. That, inasmuch as the reference of the sills, the aggregate lift of the locks, and the height of the breakwater are dependent upon the regimen of the river, as it will be established by the removal of the reefs, it is a logical sequence that the construction of the masonry of the locks and of the artificial channel ought not to be commenced until the reefs are removed.

The Board awaits the survey and estimates for the removal of these reefs and the results of the study of the cross-sections of the river at different points and at different stages before expressing an opinion as to the extent of excavation that ought to be undertaken.

In the mean time, and during the time occupied by the removal of the reefs, the systematic observations of heights of water and velocities will be a valuable element in any further consideration of the subject.

The Board sees its way with tolerable clearness through the processes

which have been indicated to the successful accomplishment of low-water navigation which may be expected to obtain for 6 months in the year. This result is not, however, without its difficulties and its serious contingencies, and one of the great advantages of the course proposed by Major Gillespie and approved by the Board is, that time will be gained for careful observation and study of what can be done and of what must not be attempted.

Some of the points which we think require study and involve difficulty will be mentioned in what follows.

Having reached the conclusion that actual construction ought to await the improvement of the navigation of the river proper, it seems hardly necessary, at the present time, for the Board to express an opinion as to the practicability or advisability of providing for high-water navigation. We are convinced, with the information before us, that high-water navigation will require the constructions spoken of as possibilities in our report of September 24, 1877, namely, that the breakwater will have to be extended to Bradford's Island, the channel behind the island excavated, and additional lockage provided at the foot.

We believe that the cost of these works has never been carefully estimated, and we recommend that this be done at some time in the future, and before the high-water system shall be again considered.

This high-water system involves one difficulty which is peculiar to itself, and another which it shares with the low-water navigation, both of which appear to the Board to be serious. We merely indicate them for the purpose of commending the study of them. The first is found in the following circumstances:

About 2,000 feet below the lower end of the breakwater as now projected, the river, at its low stage, is only 400 feet in width. The base of the breakwater, added to the 70 or 80 feet of channel inside of it, will take up about one-third of the cross section of the river, where it is already too small. Whether or not it may be necessary to make some compensation for this contraction by cutting away the northern shore, and what may be expected to be the effect of the contraction in low or high stages, are questions of difficulty and importance.

The second difficulty is due to the sliding of the hills on the southern shore. The effect of this on the proper position of the breakwater is direct.

Indeed, this final position will result from a balancing and a compromise of evils. On one side there is a sliding mountain, which threatens at any moment to fill the canal, and which ought not really to be touched in excavation. On the other side is a river channel too narrow to be encroached upon. Yet the channel must be narrowed or the mountain cut. One or both of these courses must, of necessity, be followed.

The circumstances of this work as they now appear, impress the Board with a sense of difficulty and expensiveness of construction, even for low-water navigation, and much more for a high-water system.

Under existing circumstances, with the information before the Board, we are of the opinion that operations ought to be directed to securing, for the present, merely the low-water navigation, including the medium-stage navigation if this shall appear practicable during the excavation of the reefs. The additional information that will be obtained from observations of river phenomena during the interval, and a careful estimate of cost, will, in due time, justify an expression of opinion whether or no the high-water system is practicable or advisable.

The Board has considered the proposition made by Lieutenant Powell

in his letter of July 28, 1879, transmitted by Major Gillespie, and attached to his communication marked A.

Having, however, reached the conclusion that the lock construction ought to be deferred until the low-water level at the foot of the locks, as affected by the improvement of the river below the breakwater is established, the Board does not think it necessary to express at present an opinion whether or not the plan of a single lift wall, as proposed by Lieutenant Powell, is preferable to a separation of the lifts. This question may properly be deferred until the aggregate lift is ascertained, and the epoch of resumption of lock construction approaches.

The suggestion that the effect of cutting the hill upon the location of the breakwater be ascertained in advance has already been alluded to, and is approved.

If at any time in the course of operations that we have recommended it shall appear to the engineer in charge practicable to make a test of Lieutenant Powell's proposition to supply water from the river at the head of the breakwater, to the channel inside of the breakwater, the Board would be glad to see it done. The trial will, we think, be inexpensive, and if the result proves unsatisfactory little will be lost, and something will be gained in increased channel room at the foot of the locks.

It has, however, been suggested to the Board that possibly the removal of the reefs may so reduce and equalize the current at the foot of the main rapids and below that boats may be able to reach the locks in low-water without the shelter of the breakwater.

This result would be very gratifying, and so long as there may be hope of attaining this object, it would not be judicious to undertake the construction of the breakwater, or to make a test of Lieutenant Powell's scheme.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant-Colonel of Engineers.
G. H. MENDELL,
Lieutenant-Colonel, Corps of Engineers.
G. L. GILLESPIE,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

A.

LETTER OF MAJOR G. L. GILLESPIE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., August 6, 1879.

COLONEL: I have the honor to present for the consideration of the Board the following recommendations relative to the construction of the canal around the Cascades of the Columbia River, Oregon.

In order that commerce may reap at the earliest practicable moment the benefits arising from the improvement, I would recommend that the construction be limited for the present to the obtaining of low-water navigation around the Cascades. In the prosecution of this plan it is deemed preferable to improve first the river from the foot of the main rapids to the lower landing of the Oregon Steam Navigation Company, a distance of 6 miles, by removing the principal reefs, which dam the

river and form short and steep slopes for boats to contend against in ascending.

This done, we can, with a close approximation to accuracy, determine the low-water line upon which to base the canal references, and can better determine also the length of breakwater necessary to be built in order to make an easily accessible approach to the canal during low stages. I would recommend that no masonry be laid in the construction of the locks until after the river shall have been improved, and that the existing contract be so far modified as to authorize the engineer in charge to apply the amount of the appropriation remaining unpaid in excavating the canal prism.

The appropriation of March 3, 1879, I would apply in making detailed surveys of and in improving the river. It is thought that the reefs should be blasted to a depth of at least 10 feet below lowest observed stage, but in the absence of any surveys to determine quantities, I am unable to give an estimate of the cost of the improvement. An estimate based upon the general map of the river placed the amount to be removed at 50,000 cubic yards approximately. It is probable this estimate will be increased after a careful survey has been made. As the lowest stage of water occurs in the late autumn and winter, now is a favorable time for making arrangements for the commencement of this improvement.

I submit herewith certain papers and charts prepared by Lieutenant Powell, Corps of Engineers, in local charge, bearing upon the details of the construction of the canal.

Very respectfully, colonel, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

Lieut. Col. C. S. STEWART,
Corps of Engineers,
Senior Member Board of Engineers, Pacific Coast.

LETTER OF LIEUTENANT CHARLES F. POWELL, CORPS OF ENGINEERS.

PORTLAND, OREG., *July* 28, 1879.

SIR: The following is submitted concerning changes in the plan for the Cascade Canal.

1. BREAKWATER.

This structure, being of so permanent a nature, should be located to give, with certainty, a navigable channel behind it corresponding to the width of locks. In view of the authority for the adopted lock width, the history and present dimensions of American river canals, a decrease of this width does not seem advisable. For a corresponding low-water channel below the locks, I suggest a minimum surface width of 80 feet, and a minimum width at 8 feet below this surface of 72 feet. Considering the narrowness of the river along the line of the breakwater, the great volume and velocity of water at flood stages, the permanent character of the bed, and the liability for ice gorges, it appears that the breakwater should not be thrown any farther from the adjacent shore than to secure the required channel width. I recommend that the cutting on the adjacent bank be made in advance of the construction of the breakwater.

As to the length of the breakwater, I am of the opinion that its continuation to Bradford's Island is required for *even ordinary* high-water navigation, and we should acknowledge in the construction of the canal as a fact that the back-water in the protected channel will be that due to the water surface at the foot of the island when the breakwater is completed. If the island chute is not made the low-water channel, then the back-water during low stages will be that due to the river surface opposite the opening left for the passage of boats.

The question of excavating the chute for a low-water channel, or leaving an opening, with a gate or other arrangement for closing it during high-water, is one of cost. The navigation opening, if made, should not be above the old middle landing. The thickness and ballast of the breakwater required may render it practically water-tight after a few years.

The minimum draught of 8 feet can be obtained by depression of lock No. 2 and excavation of channel below, or by supplying water from the river near the head of the breakwater. I recommend the latter method, and that the general form of the feeder in plan be that shown as the first kind of opening in the breakwater mentioned in my paper on gate pressures. The width, with different heights of the opening and velocities of the channel, are given in calculation attached herewith. The results make the fall to be overcome at low stage as 24 feet.

2. LOCK CONSTRUCTION.

I recommend a single lift-wall of 24 feet, and the addition of a lower guard (relief) gate. The best heights for this gate and the lower lift-gate are difficult to determine, on account of the problematic effect of the canal in raising the river surface. I think the walls should be made to support gates of 54 and 44 feet in height; that the thickness at the base of the inner chamber-wall should be $\frac{54}{2}=27$ feet; that the thickness at the base of the outer chamber wall should be that due to the height of flood-water opposite, $\frac{72}{2}=36$ feet (?) Protection from flood-water above the top of the lift-gate could be given by crib-work resting on the chamber-wall.

I think the walls of lock No. 1 should be constructed to support upper and middle gates of 54 and 44 feet in height.

I recommend the omission of the guard gate (in the first construction of the canal) and the heavy puddled crib-work above the locks, and the addition of a new lock next in advance of the present lock No. 1, with the new upper gate 54 feet in height. A thin breakwater, in prolongation of the outer lock walls, will be necessary, also a heavy wing-wall from the left side of the new upper gate to high ground of adjacent bank. With two locks above the lift-wall, I think that high-water navigation will be secured.

For protection against flood-water in lock No. 1, a crib-work could be rested on the outer chamber-wall, in the same manner as for lock No. 2.

As the heights of the gates, except those of the guard lock, are dependent upon the effect of the breakwater, it seems a good plan to put in the guard lock the outer lock-walls and the breakwater before completing the inner walls of locks No. 1 and No. 2.

3. MOTIVE POWER.

On account of the difficulties in the application of water power from the river, and the non-availability of a mountain stream from which a reservoir might be supplied, I recommend the abandonment of water power for moving gates and valves.

Very respectfully, your obedient servant,

CHAS. F. POWELL,
First Lieutenant of Engineers.

Maj. G. L. GILLESPIE,
Corps of Engineers, U. S. A.

REPORT OF MAJOR G. L. GILLESPIE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., November 29, 1879.

GENERAL: I have the honor to acknowledge the receipt of department letter of November 12, 1879, referring to the construction of the canal around the Cascades of the Columbia River, Oregon, in connection with the report of the Board of Engineers for the Pacific Coast, dated August 19, 1879, and inclosing certain memoranda prepared by Maj. J. M. Wilson. Before the final instructions are issued, I desire to present to the department a few facts touching the construction in its relation to the river.

The plan which I advanced to the Board, which was adopted by them in part, and of the feasibility of which I am now, after frequent careful examinations of the river at lower stages, more assured than at the time of the meeting of the Board, was that a low-water navigation of the

river to the foot of the locks for seven months in the year could be obtained without the expense of building a breakwater. I took the ground that the propriety of building the breakwater at all was questionable. If built close to the left bank, as projected, extensive excavations below the low-water line would be required, which, beyond a doubt, would occasion great local land-slides, and if the breakwater were pushed out into the stream it would make an obstruction to the outflow of the water at points where there was already too much of an engorgement. I proposed to get the navigation I advocated by opening passages through the reefs so that boats could take advantage of the eddies on the right bank, now disconnected by reason of the reefs. The reefs in the river are all alike and similar to the plateau, where excavations for the canal are going on. The underlying mass or bed-rock is very irregular in its shape; an outcropping of it at one point is no indication where it will be found 20 feet off, and its surface is covered with bowlders laid as if by the hand of a mason. By stripping the reefs of the largest bowlders for a convenient width to form a deep channel near the right bank, I am firmly convinced that boats can as readily reach the foot of the locks as they can the end of the projected breakwater. In either project *the passage of the river has to be made*, with the advantages vastly in favor of the upper point. I gave the amount of rock to be removed at 50,000 cubic yards; this included work *at all the reefs*. I now know that it is necessary to work only at the point on right bank opposite station 37, and at station 54, with a probable removal of an occasional bowlder below. The bowlders are so accessible that they can be blasted for $1.50 per yard, and $25,000 to $30,000 expended will give a practicable and convenient channel, at medium low stages, to the foot of the locks.

I wish to say to the department that the low-water navigation from September to January is worth tenfold more to this country than the navigation of the remaining portion of the year. Now, in regard to the draught of boats: During the busy season, from September 1 to January 1, when the river is of the greatest use in getting out the cereals, the steamboats between Portland and the Lower Cascades, and from the Upper Cascades to the Dalles, *draw usually from 8 to 8½ feet*. The superintendent of the Oregon Steam Navigation Company told me a few days since that that depth was sometimes exceeded; and I was further told by the captain of the Wide West, on Tuesday last, when I came down the river, that he had struck several times lately a shoal where they had always counted upon having 9 feet. He meant that his draught was near 9 feet. The draught above Celilo is of course much lower. Supposing the canal and its breakwater to have been finished last season, as projected, its miter-sill reference would have been so high as to have prohibited the use of the canal to all vessels drawing over 5½ feet. (See discussion of canal references in my annual report. The conditions are unchanged.) The Oregon Steam Navigation Company are now using freight-barges on the Columbia River below the Dalles, four from Portland and four from the Dalles. It is probable that at an early day, when the broad-gauged railroad is completed from Wallula to Celilo, for which advertisements have been published, this small number of barges will be increased to a fleet, with an expected use of our canal at the Cascades to enable them to reach Portland without breaking cargo. The present barges have an average length of 200 feet, draught 7 to 10 feet, and are towed in pairs by a steamer, also loaded to its fullest tonnage capacity. The fact is that the miter-sill draughts are dependent upon the minimum depth of low channel between the Cascades. This min-

imum depth may be assumed, deduced, or actually determined. The Board decided upon the *actual determination*, on account of the importance of every foot in the locks, whose gates are to be 54 to 58 feet high, and span 70 feet. Major Wilson's opinion about the navigation of the river at low stage corroborates in the most positive manner the conclusions of the Board which led it to reserve the artificial channel behind breakwater for high-water only. If the low-water navigation is practicable, as Major Wilson states, and can be made convenient, as the Board affirmed, it would seem a useless expense to make an artificial low-water channel of even 100 feet, to say nothing of one 11,000 feet in length when extended to Bradford's Island.

The difficulty, magnitude, cost, and liability to destruction of the breakwater by ice, and the excavation for an artificial low-water channel, seem to be undervalued. As projected, the breakwater has a length of 4,000 feet, an average width of 24 feet, and average height of 65 feet. It has (properly) close joints, and will be ballasted with stone, closely packed, to give it sufficient weight to resist outside pressures at high stage, and if not practically water-tight when first built will become so within a few years. It will rest upon a very uneven rocky bottom, which slopes both ways, and that it may possess the requisite strength and solidity the river bottom must be either blasted out or filled up to a grade admitting of a level bottom for the cribs. The blasting at that depth in such a swift current will be necessarily expensive. The filling cannot be made into a solid masonry wall, but must be spread wide as *pierre perdu* to give a good foundation, and this again encroaches upon our water-way. Supposing the foundation properly prepared, my experience in timber-work in water teaches me that cribs cannot be sunk, the superstructure carried to a height of 65 feet, and the stone filling put in at that height at a less cost than $250 per foot. This would make the cost of the projected breakwater alone $1,000,000, or, if carried to Bradford's Island, twice that sum, or more than the estimated cost of the canal and its approaches. I think Major Wilson is mistaken in the cause of the sliding of the left bank below the locks. The material overlying the sandstone moves under the action of its own weight *and the pressure behind it*—the mountain streams and the erosion by the current at high stages. The sandstone is a more permanent part of the bank, and is not eroded to any considerable extent by the river current. The land-slides, which I fear commence at the very crest of the mountain range, one can see their advance along the whole line of the range, and are simply the gradual, progressive denudation of the mountain slopes. The time will come when the Cascade Range at the Columbia River will have as barren rocky slopes as are seen in the Upper Columbia and Snake Rivers, where not a tree, shrub, or flower can be distinguished. The covering material is sliding to the base of the mountains and will eventually reach the bed of the stream. It cannot be successfully resisted by any temporary device. A breakwater to resist the degradation of the banks would but partially fulfill its office. From my knowledge of the deliberation of the Board, I can state that the Board positively declined to fix the reference of the lower lock bottom until the river had been improved, and that on account of the problematic effect of such improvement the Board recommended surveys and observations of river phenomena; the former to give estimates of cost of improvement, the latter to determine *that point during the improvement*, when the open low-water navigation became convenient, and the consequent depth required in the artificial channel for high-water. The very requirements in section 4, department letter, governed the Board in de-

ciding that the lock and artificial channel construction "should not be commenced until the reefs are removed."

The first interrogative in section 5, department letter, is answered in the negative. The low-water channel was to be in the main river, *opposite* and *not behind* Bradford's Island. The former was actually used for years by the river boats, and has been this winter by a "scow schooner" under sail; the latter channel is dry at low-water. The Board intended the island chute as part of the high-water channel only, and recommended that the cost of preparing the channel be made "at some time in the future, and before the high-water system be again considered." The main object of the attempt to improve the river for low-water navigation was to prevent "material expenditure" of work upon the artificial channel, the expense of first cost and maintenance, the difficulty of construction, and the liability to injury of which increase greatly with the depth required, and this depth increases with the increase of length of breakwater. The opening of the breakwater near the head of Bradford's Island, to be closed during high-water, was *brought before the Board*, but, having decided upon the improvement of river for low-water navigation, it was pointed out by Lieutenant Powell that the proper place for this opening was at the *head of the breakwater;* for there the width of the artificial channel, the height of structure, the depth of excavation at the foot of a sliding bank, and the encroachment upon an already engorged water-way, would be decreased and nothing lost, for the construction of the breakwater would not interfere with a previous low-water navigation. The excavation now going on is being made with a view to such an opening.

The main issue is, shall the river or artificial channel be used for the low-water navigation? If the former, ought the river improvement to be made before lock construction? And, for the high-water system, is it desirable to enlarge the water-way in the river by partial removal of reefs, and by stripping the sharp points of banks of their massive bowlders to compensate for encroachment upon the river by the breakwater? The cost of river improvement is certainly small when compared with that of an artificial low-water channel. *The present and urgent* need is for low-water navigation; and I strongly advocate river improvement on account of its cheapness, readiness with which it can be made, and the early day which may be given for opening the canal to low-water navigation. The winter is so far advanced that the entire appropriation cannot be profitably expended, even if deemed expedient, this season; but, as I have stated, $25,000 may well be applied at the places offering greatest obstacles to navigation, the result on the present low and next high water required observed and the canal references fixed with a margin for safety.

No new buildings will be required for the laboring force near the site of the improvement, as the buildings at the locks will be sufficient, and the force can be ferried to and from their work.

I respectfully ask a patient consideration of the foregoing in connection with the report of the Board, and if the department still thinks that it is not expedient to attempt to gain low-water navigation in the manner herein outlined, I shall execute to the best of my ability the plans heretofore projected and approved.

Very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

M M 5.

IMPROVEMENT OF THE MOUTH OF COLUMBIA RIVER, OREGON.

In compliance with the river and harbor act approved March 3, 1879, a survey of the bar at the mouth of the Columbia River was made under instructions from this office by G. M. Jessen, assistant engineer, August to October, 1879, in continuance of the survey of the previous year, and to comply further with as much of the river and harbor act of June 18, 1878, as required a thorough survey of the bar and the preparation of a plan and estimates for its permanent improvement.

Mr. Jessen completed the survey in October, 1879, and his report, which was submitted to me December 4, was transmitted with mine to the department, dated December 19, 1879.

The north channel, especially at the shoal east of Sand Island, has continued to shoal since the date of that report, and at very low tide, when the sea is rough, no vessel or steamer drawing over 17 feet will attempt to cross the shoal, preferring to remain at the outer anchorage in Baker's Bay until the advance of the flood.

I made an attempt during two weeks in January to deepen the water over this shoal by the use of the scraper attached to the dredger, the only means I had, but I could succeed only in reducing the crests of the deposits with an increase of depth of barely 1 foot. Late examinations at Sand Island and across the middle sands westward of Sand Island led me to infer that, after the summer freshet of the Columbia has subsided, nature will have corrected unaided the difficulties shipping has experienced the past year at the entrance to this river, by the opening of a deep channel through the middle sands at the "Swash," which was predicted in my first report of December 18, 1878, or a little to the southwestward, near where the present range of the Sand Island beacons extended crosses those sands.

The citizens of Astoria are anxious that some extensive work of improvement should be taken in hand to increase the depth of water *over the bar*.

The plan proposed in my report of December 19, 1879, had in view only the correction of the immense deposits which have been made in past years on the *inside of the bar*, tending to shoal the outer harbor and the approaches to Baker's Bay. From the nature of the circumstances there always will be a bar at the entrance, and no local improvement can prevent its formation; but it is a question for long investigation whether it be not possible to give a direction to the ebb currents by contracting the outlet from the inside that will keep open a straight channel directly westward through the present Middle Sands out and over the bar, so that there may be fewer detentions arising from shoal water on the inside. It is not possible to estimate the advantages arising from such a result. The execution of any plan proposed as a remedial measure will cost a great deal of money and will consume a great deal of time, and the interests involved are so extensive that great caution should be used against a hasty commencement of immature plans. I am not prepared to say at this time that the plan proposed by me is the best to be followed. I can only say that it is the only one which my present knowledge of the locality and its exposure will permit me to present for the consideration of the department.

The south channel, like the north channel, has shoaled to a great extent during the year, the result, it is believed, of the severe southerly storms which prevailed with short interruptions from November to

March. These storms have likewise, by their long continuance, at times raised the water in the outer harbor to such unusual heights that at high-tides, when a strong southerly wind was prevailing, the waves have swept up along the beach in front of Fort Stevens and toppled over into the ditch without doing any special injury to the fort, though not without exciting great fears on the part of the commanding officer that the fort was being endangered, and that the erosion of the beach to the westward might increase so rapidly as to open a channel for the sea between the buildings of the garrison and the fort.

In March, 1880, the usual annual survey was made of the shore line of Point Adams and Clatsop Spit. It shows that since the last annual survey the shore line on the northwest of Point Adams has moved in a southeasterly direction from 25 to 180 feet. The injury to the shore has occurred principally above high-tide line by the waves cutting under the soft loam and causing the crest to fall over.

This erosion is not followed by deep water along the face of the beach, but, on the contrary, the beach seems to be extending outwards on that side, gradually following the eastward extension of Clatsop Spit.

Indian Mound, a small hillock 10 feet high, lying west of the fort, has lost its western half by the erosion which occurs in very rough weather in spring-tides. Northwest of the fort, in front of the rubble wall built in 1877, the high-tide line has for the same reason advanced 140 feet, approaching the east end of Clatsop Spit, which is moving eastward progressively.

On the northeast side of the fort the beach has gained throughout the year, but the high-tide line has receded nearly 40 feet. The axis of Clatsop Spit has moved eastward 400 feet, its northern end 250 feet northward, and its eastern end 400 feet eastward.

Whilst the changes here noted have been going on along the main shore, an inspection of the comparative chart which accompanies this report will show that an equally important and significant change has occurred in the dimensions and depth of the lagoon at the base or shore end of Clatsop Spit.

As long as that lagoon remained deep and large, and was filled by every flood, a deep and wide outlet was kept open near Indian Mound. During the past year the lagoon has been rapidly shoaling, and a sand island, first appearing on the exterior in 1876, has continued to move bodily towards the eastward until at last the outlet of the lagoon is almost closed at low-tide.

Just at this point—the outlet of the lagoon—is where all the erosion has been taking place of late, but I am of the opinion that it has reached its maximum, and that during the summer the lagoon will be filled up, that the sand island will form part and parcel with the main shore, and that the high-tide line will advance outwards from Indian Mound, and the main shore at that point be securely protected against further erosion. Should natural causes not bring about this result, it may be necessary to build a brush and stone revetment along the face of Indian Mound to encourage the growth of a beach there and protect the shore against inroads by the waves. Such a revetment should not be less than 2,000 feet long, and it is estimated that it will cost $10 per running foot.

The annual survey of Sand Island shows that the northwest end has moved 800 feet westward and 1,390 feet northward since the survey of 1879. The southeast part is unchanged. The narrowest point near the middle is now 500 feet across, against 840 feet in 1879.

The island is gradually crowding against the north channel, making it narrower and shoaler each year.

The following statistics, required by act June 23, 1866, are respectfully submitted.

The appropriations for this work have been as follows:

Act of June 18, 1878	$5,000 00
Act of March 3, 1879	5,000 00
Total	10,000 00

The harbor is in the collection district of Oregon. The nearest port of entry is at Astoria, 12 miles from the entrance. There is a light-house and work of defense on each side of the entrance.

Amount of revenue collected at Astoria during the eleven months ending June 1, 1880	$29,126 00
Value of imports	$28,276 00
Value of exports	$1,973,221 00
Vessels entered, 229; aggregate tonnage	355,917
Vessels cleared, 249; aggregate tonnage	380,619

Money statement.

July 1, 1879, amount available	$5,000 00
July 1, 1880, amount expended during fiscal year	5,000 00
Amount (estimated) required for completion of existing project	20,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	20,500 00

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1880.

COLONEL: I have the honor to submit the following report of the surveys of Point Adams and Clatsop Spit, and of Sand Island, at the mouth of the Columbia, made during the last week in March of this year, with the respective charts; also comparative charts showing the movements of the shore lines as shown by the surveys made annually since 1868, the date of the first surveys made under the direction of this office.

POINT ADAMS AND CLATSOP SPIT.

The following are the principal changes here since April, 1879:

The high-tide line of Clatsop Spit has advanced northward 340 feet, and the beach between the high and low tide lines at the north end of the spit became steeper; the axis of the spit has moved eastward 400 feet, its eastern extremity at high-tide line being now only 250 feet from the shore line of Point Adams, nearly closing the Swash Channel, which is thus converted into a lagoon. Within the lagoon shoaling has reduced the general depth to from 1 to 6 feet, except at one point opposite the mouth of the principal outlet of the marshes back of the fort, where the depth is 19 feet; 7 feet of this being due to the bar formed across the mouth of the lagoon by the eastward growth of the spit, whereby all tides, except very high springs, are excluded.

Formerly, before the formation of this bar, the depth at this point was 19 feet at low-water, showing a shoaling up to the present time of 7 feet here.

The lagoon contains a number of large drift trees, brought in over the bar by very high-tides. The spit appears to be rapidly approaching a junction with Point Adams near the western extremity of the sea-wall built in 1877.

The shore line of Point Adams on the north, northwest, and northeast of the fort has not changed materially during the last year. During the extraordinarily high-tides and stormy weather which prevailed last spring, the waves made a breach 30 feet long in the fence northeast of the fort.

West of the fort for 2,000 feet along the shore of the lagoon, at high-water level, the bank has lost from 50 to 180 feet in width, from the beating of the small waves generated inside of Clatsop Spit by westerly winds. The least distance from the shore of the lagoon to the fence west of parade ground is 370 feet.

The soundings, which, owing to bad weather, could not be made until the end of May, show that northeast of the fort the depths at some points are from 3 to 8 feet greater, and at others from 2 to 5 feet less, than in 1879. The principal change in the

general contour of the bottom appearing along the curve of 6 feet depth, which is 100 feet nearer to the low-tide line.

Over the submerged portion of Clatsop Spit the depths near the shore line are greater by from 3 to 4 feet. The head of the spit opposite Sand Island is said to have shoaled so much as to be nearly awash at extreme low-tide. At the time the survey was made the sea was so rough that this shoal could not be sounded, or even approached near enough to allow close examination.

The chart of the first United States survey of the mouth of the Columbia, made in 1841 by Commander Wilkes, United States Navy, shows the Indian village of Clatsop 1 mile north-northwest of the point where Fort Stevens now stands, while the high-tide line to the west-northwest was 5,030 feet distant from the present line of the west fence. In 1868 the high-tide line was found to have traveled 2,870 feet in a south-easterly direction. Its progress since then, in the same direction, as is shown by the annual surveys, has been found to be—

	Feet.
In 1869	80
In 1870	40
In 1871	305
In 1872	190
In 1873	173
In 1874	24
In 1875	150
In 1876	158
In 1877	75
In 1878	330
In 1879	38
In 1880	197
Total since 1868	1,760
Total since 1841	4,630

The average distance moved annually having been 119 feet since 1841.

The erosion was not confined to the west side of Point Adams, but extended all around the point, and in 1877 had approached to within 40 feet of the fence north of the fort.

The sea-wall built the same year arrested its progress, and to some extent repaired the injury, the shore line having since retrograded 130 feet.

SAND ISLAND.

The survey here shows that the northern extremity of the island now lies 1,700 feet in a north-northwesterly direction from its position in April, 1879, the south shore having also moved northward 240 feet, and that the width of the island has been reduced from 900 to 500 feet, near the middle, as if it were about to be cut in two.

The range beacon on the south side is now only 100 feet distant from high-tide line. Since 1868, the southern shore-line has moved northward 2,335 feet, or on an average nearly 200 feet yearly.

Respectfully submitted,

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major of Engineers, U. S. A.

SURVEY OF THE BAR AT MOUTH OF COLUMBIA RIVER, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 17, 1879.

GENERAL: I have the honor to submit the following report on the survey of the bar at the mouth of the Columbia River, act March 3, 1879, embodying a plan and estimates for its permanent improvement, in compliance with the requirements of river and harbor act of June 18, 1878.

I was not able to obtain the services of the officer who had personal charge of the survey made during the summer of 1878, but his place was filled by Capt. G. H. Jessen, the assistant engineer, who made the survey of the bar in 1876, and to whom I am greatly indebted for a

most faithful and satisfactory discharge of the duty assigned him. I submit herewith the report of Captain Jessen.

It will be observed that a few very marked changes have occurred since last survey. The northwest end of Sand Island has moved northward about 1,300 feet, and the east end to the eastward about 300 feet. Whilst the outer part of the north channel immediately south of Cape Disappointment has maintained its usual great depth of water, the inner part north of Sand Island has greatly contracted in width without any special diminution of depth except at the east end of Sand Island, where the shoal of last year has widened, and there is barely 16 feet at low-tide. This channel, notwithstanding the increased shoaling on the inside, is now used by deep draught vessels to the practical exclusion of the south channel. The south channel has materially changed both in depth and width, and the observable growth of scattered sand lumps in the outer reach indicates a strong tendency of the outer bank to close upon the channel, forcing it nearer the shore line. At the date of my last report, December 18, 1878, it was stated that the deepening of the water on the submerged middle sands westward of Sand Island, near the crossing of a line from Cape Disappointment to Point Adams, foreboded the opening at that point of a deep-water channel directly seaward from the south channel. It was thought at that time that the decline in the south channel would progress at a slow rate until the opening of the winter months, then that channel might possibly be entirely closed under the cumulative action of the southerly storms, and the new channel opened immediately thereafter. These results, however, have not been fully realized. The southerly end of the middle sands has encroached gradually upon the outer reach of the south channel, diminishing its depth throughout, but the deepening near the center of the middle sands has ceased, giving but little prospect that the expected new channel will be formed there at an early day; owing probably to the compactness and firmness of the sand at a depth below 12 feet low-water and to the irregular action of the currents consequent on the shoaling of the south channel. There is, however, a deepening of the middle sands 2 miles to the southward and westward of Sand Island, and slightly north of where the line of range beacons on the east end of Sand Island crosses the middle sands. It would seem that this latter point is now the weakest part of the middle sands, and the most probable location of the channel which is to follow the decline of the south channel. After weighing all these changes and considering their effect upon the commercial standing of the port, we may say that the south channel has so far declined as to seriously diminish its usefulness to sea-going vessels, and that there is a probability of a better channel forming to the northward distinct from the main north channel, the exact location of which cannot be defined with definiteness. At medium tide the entrance by the north channel, behind Sand Island, is easy and convenient for vessels drawing not to exceed 21 or 22 feet.

I now enter upon the subject of improvement. The building of a breakwater in the open sea, to cover so wide a harbor entrance, and resting upon such an unstable foundation and exposed to such terrific seas, is an undertaking which any engineer may well hesitate to recommend and tremble to commence. The shore-line of the harbor on the north side is of a very enduring nature, and can never be worn to a dangerous extent by the action of the seas, whilst the south side is a comparatively low spit, composed chiefly of sand, heaped up by southerly storms, and constantly undergoing changes in its shore-line as the results of these storms. Between the most westerly points of the two

shores the sands of the sea have accumulated into vast submerged banks, through which there are usually two channels for deep-draught vessels, though the most southerly one is seldom maintained in the same unchanging direction for five consecutive years. It is possible to close the northerly channel by running a low-water dike from Chinook Spit to Sand Island, but this would shoal Baker's Bay and destroy its usefulness as an anchorage for war vessels in their defensive relations to the batteries on the cape; and besides, might, by the destruction of Point Adams, widen the entrance to the southward, and give no better or more permanent entrance on the south side than now exists. If this be true, we must then look to the south shore for the location of a work of improvement, and that improvement must be so made that it shall not obstruct the flood tide, and shall give the ebb that direction which will make its scouring influence most effectual in preventing the formation of shoals in the channel on the north side. The improvement which seems most nearly to answer this requirement is a low stone dike, extending from the inside of Point Adams, near Fort Stevens, along the east edge of Clatsop Spit to the 4-fathom curve in the south channel. The dike should rise not to exceed 3 feet above low-water, and should be built of heavy loose stone, placed irregularly, by dumping them from the decks of scows, or from a tramway on piles sufficiently elevated to be independent of the highest waves.

Adopting the general plan of breakwater proposed by the Board of Engineers for the Pacific coast, February 14, 1877, for the harbors of refuge on this coast, a dike 25 feet wide at top, built in 24 feet water, will have a base of 166 feet. To reach the 4-fathom curve in the direction assumed, the dike would require to be 10,000 feet long. During storms from the southward the waves break heavily at the entrance to the harbor, almost normal to the line connecting Cape Hancock with Point Adams. This line is practically the one which the proposed dike will follow. It would seem at first thought that the dike, from its exposed position and direction, would be required to withstand the full force of the waves, and should, therefore, be more than ordinarily massive; but when it is considered that the middle sands almost completely encircle it on the northeast side, and Clatsop Spit offers a wide shoal barrier of defense on the west, we have reason to anticipate that the wave forces will be much broken before they reach the dike, and will expend themselves harmlessly against a well-built structure. The sand which would be formed behind the dike during long-continued storms might be carried over the dike into the channel on the inside, but it is thought that it would be in such quantities only as would be easily carried by the ebb tides beyond the point where it could accumulate into an obstruction at the entrance to the harbor. The sand is so unstable where the dike will be located, that it is probable that a strong foundation of timber, in connection with mattresses, will be required to be sunk to prevent irregular settlement of the stone covering. An examination has been made of the hills bordering the harbor and along the banks of the tributary streams, to ascertain where stone of a suitable kind and in large quantities can be found. But few quarries have been opened for procuring stone, but the surface examinations show that suitable stone abounds at many accessible points.

It is estimated that a rubble stone dike 10,000 feet long, built to the 4-fathom curve, will cost as follows:

850,000 cubic yards large rubble blocks, at $5 per cubic yard	$4,250,000
Contingencies	500,000
Total	4,750,000

It is practicable to make a training wall for the ebb waters by substituting for the stone dike a double or triple row of piles, and filling the spaces with fascines and stone. Such a temporary and experimental dike is, however, not recommended.

A great deal has been said and written about the dangers of the Columbia River Bar, but I think a careful examination of the list of disasters which have occurred there, and the causes which have occasioned them, will prove to the reflective mind that they have been greatly and unjustly magnified, and that the entrance to the Columbia River has no obstructions peculiar to itself, or not found in the approaches to other harbors of equal importance or magnitude. It should be remembered, when comparing this harbor with others, that there are usually two channels crossing the Columbia River Bar, affording nearly equal depths of water, and enabling vessels to take that one which is most favorable under the winds and seas prevailing at the time. The north channel, under Cape Disappointment, is usually open and unobstructed, but the south channel changes from year to year in direction, depth, and width; sometimes is superior to the north channel for a short period, and then again very inferior to that channel; but at no period within the knowledge of any one has there been a time when there was not *one good deep channel* across the bar, affording an ample depth of water at high-tide to the inner harbor for vessels of the deepest draft. I know of no bar at the mouth of a great and mighty river which has a better record than that of the Columbia River; and if it be advisable to make an improvement which will utilize permanently the greater part of the ebb-tides along one channel, it can scarcely be doubted that the inner middle sands will be practically destroyed; that the bar will be moved farther seaward, and that the world will be made to cease repeatin theg idle stories prejudicial to the Columbia River entrance.

The harbor is in the collection district of Oregon. Astoria, 20 miles from the bar, at the entrance, is the nearest port of entry. There is one light-house and one work of defense on either side of the entrance.

Amount of revenue collected at Astoria during the 11 months ending June 1, 1879	$21,071 31
Value of imports	565 00
Value of exports	1,953,033 00
Vessels entered, 234; aggregate tonnage	399,663 tons.
Vessels cleared, 269; aggregate tonnage	435,063 tons.

I am, general, very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Brt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, *U. S. A.*

REPORT OF CAPTAIN G. H. JESSEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 4, 1879.

SIR: I have the honor to submit the following report of the survey of the mouth of the Columbia River, Oregon.

In compliance with your letter of instructions, dated August 12, 1879, I at once proceeded to Astoria and organized my party, consisting of two sextant observers, two angle plotters, one recorder, two leadsmen and two tide-gauge keepers. Work was commenced on the 22d of August, by the erection and location of ten signals on the Washington Territory side and seven on the Oregon side of the river. Three signals were also located on and near Sand Island. For triangulation the distance between

Cape Hancock light-house and the flag-staff at Fort Stevens was used as a base-line, a distance of 10,073.8 meters according to the United States Coast Survey of 1868.

The work of triangulation was completed on the 24th of August, and sounding commenced on the morning of the 25th. Whenever the weather and the favorable condition of the bar permitted, soundings were made as rapidly as possible outside: the inside soundings were made when it was found impossible to work with any accuracy on the outside on account of the rough water, which generally takes place in August and September in the afternoon, when the strong winds set in from the northwest.

The method used for the survey was the same as is generally employed by hydrographers in similar work, a tugboat was used, steaming at a rate of 4 or 5 miles per hour, according to the different depths of soundings, the positions determined by two simultaneous sextant angles every 5 minutes, or at shorter intervals whenever found necessary; soundings were taken every 30 seconds and plotted on a scale of 1-20,000.

Two tide-gauges were established—one at Fort Stevens wharf and the other at Fort Canby wharf (Cape Hancock). The readings of both gauges were simultaneous every 15 minutes while the survey was in progress. These gauges were carefully compared at low-water with the gauge at Astoria, the latter gauge having been set by the bench-mark established by the United States Coast Survey in 1853, and is 9,547 feet above the plane of reference to which the soundings on the chart are given.

There is very little change in the general direction of the deep-water channels from the previous surveys of 1876, and the survey made by Lieut. A. H. Payson, Corps of Engineers, U. S. A., in 1878. The depth in the north channel on the bar is the same as last year, being 23 feet at mean low-water. In the south channel, however, the bar has decreased in depth from 1 to 1½ feet since the survey of 1878, and is at present 800 feet wider between the 18-foot curves on the outer edge of the bar, and nearly the same width on the inner edge. The middle sands immediately west of Sand Island, where the north and south channels are only about 3,000 feet apart, and over which it was thought last year a new channel was forming, has only 13 feet of water: there is no indication that this depth is increasing, in fact it would appear that it is diminishing. The current on the flood-tide sets across this shoal in a N. N. E. direction with a maximum velocity of 1.2 feet per second, and the ebb-tide, passing down north of Sand Island where the bold and rocky shore of Cape Hancock changes its course, runs over the shoal with a velocity of 1.5 feet per second in a S. by W. direction, where, after passing the shoal, it joins the current in the south channel, and sets S. W. across the middle sands.

Since the survey of 1878 Peacock Spit (a mile south of Cape Hancock Light) has made about 1,000 feet to the southeastward, which is the only change in the north channel until it reaches the N. E. side of Sand Island; here the channel between the 18-foot curves has become very narrow (700 feet wide), and has decreased in depth from 20 feet to an average depth of 19 feet at mean low-water, running in an E. S. E. direction.

The shoal at the head or east side of Sand Island has an average width of about 3,000 feet with a depth of 15 feet at low-water. On the S. E. side of this shoal at Station C, the current (ebb) sets W. by N. with a maximum velocity of 3.6 feet per second. At Station D, about ½ mile S. S. E. from Station C, the current sets also W. by N., passing on the south side of Sand Island, with a velocity of 3.0 feet per second. Between these two stations, at a depth of about 25 feet, the current appears to divide, running with about equal velocity north and south of Sand Island, the larger portion of this volume of water evidently flowing to the south of the island and possessing strong, eroding power, as the submerged beach on the south side of the island falls abruptly from the shore-line to a depth of 40 feet, where the center of the island was ten years ago. The N. W. end of the island has since last year's survey made 1,300 feet to the N. W., and increased in width from 1,100 feet to 2,500 feet while the east end has also made to the eastward 300 feet.

To the eastward of the line joining Scarbrough Head and Fort Stevens, no perceptible changes have occured since the survey of 1868.

At Station I, Chinook Channel, the ebb-tide sets W. ¾ N. with a maximum velocity of 3.2 feet per second. The flood-tide at the same station sets in an E. by. S. direction with a maximum velocity of 5.5 feet per second, an increase of 1.4 feet per second over Station I, caused by the meeting of the north and south channels below this point. In the middle channel, at Station G, the ebb-tide sets W. ½ N. 3.0 feet per second, and the flood-tide at the same station changes its direction from S. S. E. to E. by S. with a maximum velocity of 0.7 foot per second.

The ebb-currrent in the main channel at Station F, nearly east of Fort Stevens, sets N. W. by W. ½ W., with a maximum velocity of 5.0 feet per second, and the flood at the same station 1.5 feet per second in opposite direction to the ebb.

The middle sands are situated to the westward of the line connecting Point Adams and Cape Hancock and run nearly north and south, covering an area of about 4 square miles. There is found an increased depth of water since last year's survey.

This is demonstrated by the fact that in the survey of 1878 it was found impracti-

cable to run more than a few lines across the sands, owing to the low depth of water. The present survey shows an increased depth and a new channel forming, which at present has a depth of 14 to 15 feet at mean low-water on the prolonged line of Scarbrough Head and Clatsop Spit; here the sands between the 18-foot curves are about three-quarters of a mile wide and about half a mile between the 15-foot curves, showing a slight decrease in width from the east side since last year. If the channel east of Sand Island remains open so as to prevent the current from the south channel from setting across the sand immediately west of Sand Island, the lower channel will no doubt in a short time be the main channel, straight and deep for some years to come. The decreasing depth in the outer reach of the south channel, or on the bar proper, has a tendency to throw the current in a straight course through this new channel. North of this channel there lies a shoal one mile square, with an estimated depth of 7 to 8 feet at low-water; there is another shoal south of the channel about a half mile square with the same estimated depth. On these two shoals, which are parts of the main middle sands, the sea breaks almost constantly.

The velocity of the current on the ebb-tide on the east side of the middle sands runs at a rate of about 1.5 feet per second in a S. W. direction, and the velocity in the south channel at the inner black and white buoy is about 1.2 feet per second, and sets to the S. S. W.

The south channel has not been used for the past three months except by light-draught vessels in ordinary weather. Occasionally, however, with a smooth bar and a high tide, deep-draught vessels, drawing from 21 to 22 feet, have crossed out to sea by this channel, although they are delayed frequently from 10 days to 2 weeks waiting a favorable opportunity to cross the bar.

There is now 19 feet at low-water in the south channel, but on account of the numerous 18-foot shoals across the channel which nearly connects the 18-foot curve of the middle sands with that formed by Clatsop Spit, this channel is practically closed to the larger class of ships.

The action of the sea has since the survey of 1868 moved the middle sands in a southeasterly direction, and it seems now that in a short time the 18-foot curve of Clatsop Spit and the middle sands will be joined across the channel. This gradual shoaling indicates a deepening in some other place, and nowhere is it more plainly seen than in the channel across the middle sands.

The north channel is now used by ocean steamers and the deepest-draught vessels, as it has 4 feet more water than the south channel and runs in a direction at right angles to the seas, thus possessing a double advantage over the south channel for entering, which course over the bar now is winding somewhat like the letter S, and the vessel is broadside to the seas almost constantly, both going out and coming in.

The shoal at the head of Sand Island is easily crossed at high-tides by vessels not drawing over 21 feet, as the swell here is greatly diminished by the protection of the island.

Respectfully submitted.

GUS. M. JESSEN,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major, Corps of Engineers, U. S. A.

M M 6.

IMPROVEMENT OF THE ENTRANCE TO AND HARBOR OF COOS BAY, OREGON.

There was available, at the beginning of the fiscal year, for this improvement the sum of $40,000 appropriated by act of March 3, 1879. The project for the application of this appropriation submitted by me to the department April 19, 1879, was referred for consideration to the Board of Engineers for the Pacific Coast May 13, 1879, I being appointed an associate member with the Board during its deliberations on the improvement.

After a personal examination of the harbor, the Board assembled in Portland, Oreg., August 6, and submitted a report to the Chief of Engineers, which received the approval of the honorable the Secretary of War November 24, 1879.

The plan adopted consisted of the "construction of a jetty from a

Cedar broom-handles	220,000
Bed slats	23,100
Spruce staves	12,300
Myrtle in logs	76,000
Ship knees	361
Coal (2,240 pounds to the ton) ... tons..	46,270

It is impossible to state the extent to which commerce will be benefited by this improvement, but assuredly if better water in the lower harbor and a more direct channel over the bar can be maintained all the lumber and coal interests bordering the bay will be greatly increased in amount and enhanced in value, and the mills and mines will be kept running on full time throughout the year, which is not the case at present.

Money statement.

July 1, 1879, amount available	$40,000 00
July 1, 1880, amount expended during fiscal year	24,357 72
July 1, 1880, amount available	15,642 28
Amount (estimated) required for completion of existing project	932,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	60,000 00

REPORT OF LIEUTENANT A. H. PAYSON, CORPS OF ENGINEERS.

MARSHFIELD, OREG., *June* 30, 1880.

COLONEL: I have the honor to submit the following report on the improvement of the harbor at Coos Bay, Oregon, for the fiscal year ending June 30, 1880.

I reached this place to take charge on February 5. At that time an agreement had been made with H. H. Luse to supply stone, and with E. B. Dean & C. for timber and iron; but beyond this no steps had been taken. Luse had yet to build scows, while his mill had been badly wrecked by an accident, and he was waiting for machinery and tools from San Francisco. On the 12th he began four large scows, and preparations for building cribs were commenced with a few men at Marshfield.

The months of February and March were nearly an incessant storm, and work outdoors was thereby almost entirely prevented. By taking advantage, however, of every favorable opportunity, two scows had been launched by the end of the latter month, and three cribs carried to a height of twelve courses.

An examination of the different places where rock could be had decided me to use the ordinary sandstone. The so-called black rock (metamorphic sandstone) was in some places heavier, but in other parts of the same ledge lighter, on account of a large mixture of calc spar. Beside this lack of uniformity it was harder to quarry, and cost 50 cents more per cubic yard. Borings, taken as far out along the site of the work as circumstances would admit, established the fact that the bottom was a flat shelf of rock for about 800 feet, with sand only in occasional crevices. It was therefore unnecessary to use riprap for stability, and considering the experimental nature of the work, desirable to omit it, in order to secure the greatest length possible, with the present appropriation.

The first crib was finally sunk on April 6. Since then work has been carried on as rapidly as possible, and there are now eight cribs in place, giving the wall a length of 400 feet. Four other cribs are also nearly built. This slow progress is to be explained as follows:

The stone quarry is 24 miles away from the jetty, and of this distance 12 miles are in a shoal and narrow river, down which but one scow can be towed at a time, and that takes an entire tide. The site of the wall is behind a submerged sand spit, which it is designed to cut away. On the ebb the water is smooth, but soon after the change to flood, in nearly any weather, a sea comes in over this spit from the bar outside which would make it impossible for scows to discharge. It is necessary, therefore, to put the crib in place in high-water, and secure it during the following ebb.

Finally, during the past month and a half, the summer northwest winds have blown with such violence as to prevent work after 9 or 10 a. m., and the time for sinking has therefore been still further restricted to such high-water as comes about day-break.

Owing to the character of the bottom the cribs once down and filled were perfectly secure, and no protection in front of them was necessary.

The only difficulty so far met with has been the rapid current. Hard to handle in

still water, cribs are perfectly unmanageable, even by a powerful tug, in such a tide-way. It has been necessary to place them precisely at slackwater, and this is of such short duration that a delay or miscalculation of only a few minutes has several times resulted in complete failure. When the bar is rough, moreover, even at slackwater, the undertow will prevent work. No moorings will hold after the tide begins to run, and to keep it in place each crib has been fitted with two spuds, or grausers, at its outer end. As soon as it was swung into line from the moorings these were let go, and so secured by wedges that the falling tide quickly brought a part of the crib's weight upon them. This was found a perfectly simple and effectual arrangement, and had the additional advantage of helping to hold the crib up, when the bottom was uneven, until stone could be thrown underneath. The last two cribs placed were of such deep draught that they could not be taken down the bay from Marshfield. It was necessary either to put on the upper courses after the cribs had been towed below, or else to lighten them.

The first plan would have made it necessary to form some artificial shelter at the jetty, since one of the worst obstructions is the shoal just above, at Rocky Point. Two boxes, or pontons, were therefore built of enough lifting power to raise these cribs four courses. These were secured under timbers projecting through holes pierced in the end walls, and released when in deep water by cutting these timbers away.

On account of the necessity before explained of sinking at high-water, the wall has been built from 1 to 2 feet higher than it should be theoretically, but cutting it down to the proper reference will be a small task.

The only result which can be credited to the jetty thus far is a wide and shallow depression in the spit opposite, through which water flows during all but the lowest tides. The sands, above and below this passage, seem also to have gained in height, and made in, but their form changes so rapidly and frequently, under the action of natural causes, that it is impossible to say what part the jetty has borne in this movement.

As regards effect on the channel over the bar, none can be observed, nor has the work been carried far enough to justify the expectation that any would be.

Though 20 feet of water has been reached, the main channel-way, with depth of from 40 to 50 feet in it, lies beyond, and not till that has been turned in the desired course can we hope for any considerable change in the existing conditions, or reliable evidence whether or not the experiment is likely to prove a success. Unless, therefore, an additional appropriation is secured, the amount of the last has been worse than wasted, for there is reason to fear that the wall, if left incomplete, may act harmfully in shoaling the present channel by the loss of water passed out through the new and imperfect one cut across the spit. Moreover, to secure the greatest length possible with the money, the jetty has been built of perishable material, and unless the necessary extension is made within two or three years there will have to be a certain outlay for repairs.

There are other considerations to be urged in favor of a speedy completion of this work.

Coos Bay is a type of the only class of harbor on the coast from San Francisco to the Straits of Fuca. In the first class of these is the mouth of the Columbia; in the second, come Humboldt and Coos Bays and the Umpqua: after these a somewhat numerous list of such as the Roque, Coquille, and Eel Rivers, and Yaquina Bay. Varying, as they do, in local features, in general character they are the same, and the only radical difference between the mouths of the Columbia and Coquille is in size. In all we find a tidal prism apparently large enough to secure a much better outlet than they usually have, and across the entrance a bar of pure sand, formed by wave action alone without sediment from the stream, across which the best water is found in a constantly shifting channel. These changes are more frequent and proportionally greater as the place is smaller, while in all cases where we have reliable information, extended through a term of years, some one position of the channel is the most favorable as regards either depth of water, direction of prevailing wind and sea, or both.

Owing to the violence and size of the seas in winter, any attempt to concentrate the scour by walls, carried out over the bar proper, may be regarded as well-nigh impracticable, and the question has been raised whether this favorable direction to the channel might not be given by a construction, built from inside, as far out perhaps as the spits, but sheltered by them from the full force of the waves.

A costly experiment in answer has been begun at Coos Bay: large interests are now pressing a similar effort at the mouth of the Columbia, while the increasing wants of commerce along a coast otherwise destitute of closed shelters will each year more urgently demand some attempt at the improvement of many other barred entrances. As a precedent, therefore, the work now in progress at Coos Bay gains an importance beyond the present or probable needs of commerce there, and in carrying it on to a logical conclusion the money spent will not have been quite wasted, even in the event of failure. The length to which the wall will have to be extended can only be determined by the results obtained as the work progresses.

As before stated, a flat shelf of rock is known to extend out some 800 feet along the line of the jetty, and the whole of the present appropriation will probably have been spent before that length is reached. Afterward sand overlies the rock, to what depth has not been acertained on account of the great depth of the water and the lack of any appreciable slack at the turns of the tide. In such rapid currents I believe that cribs placed on the sand will, however heavily riprapped, sink to the solid bottom, and it will probably therefore become necessary to give up their use and resort to some other method of construction—for instance, rafts of young trees with intervening layers of stone. In any case, the outer part of the wall will need a much larger proportion of stone than has heretofore been used, and lying as it will in the deepest water and swiftest tideway its construction will probably be attended by many unforeseen difficulties.

For these reasons it is impossible to give any exact estimate of the amount necessary to finish: but I think that $60,000, beside being about as much as could be well expended here in one working season, would carry the line out to the present inner edge of the north spit. This done, the inner channel has been forced entirely into the new and desired direction, and if any good results are to be hoped for on the bar their indications will by that time have been obtained.

Very respectfully, your obedient servant,

A. H. PAYSON,
First Lieutenant of Engineers.

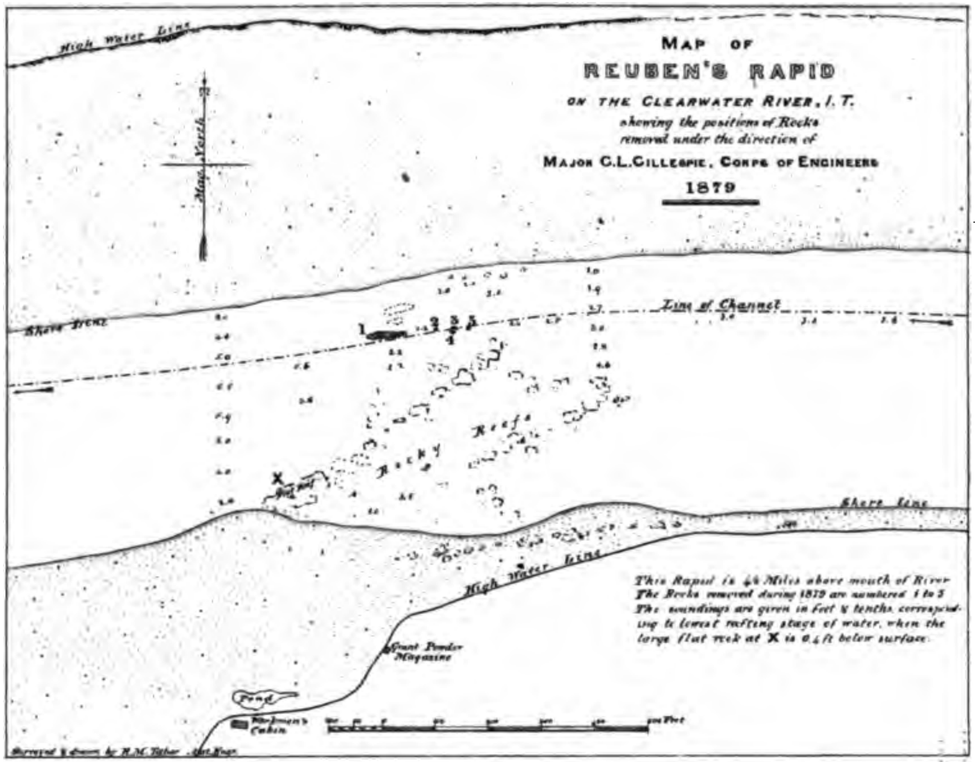
Col. G. L. GILLESPIE,
Major, Corps of Engineers, U. S. A.

M M 7.

IMPROVEMENT OF THE LOWER CLEARWATER RIVER, IDAHO.

The amount available for this improvement at the beginning of the fiscal year was $5,000, appropriated by act of March 3, 1879. The section of the river embraced within the limits of practicable improvement extends from Lewiston to the mouth of the North Fork, a distance of 40 miles. The river varies in width from 60 to 1,000 feet, the bed is covered with large gravel and cobble-stone, and there are many rocky reefs distributed along the section where the channel is choked by high projecting lumps or spines, through which it is not safe for any but small boats to attempt to make a passage at low stage.

After public advertisement, in the usual way, sealed proposals for commencing the improvement were opened in this office September 23, 1879, and a contract was made October 16, 1879, with Silas R. Smith, of Lewiston, for the removal of 115 cubic yards of solid rock from the channel at Reuben's Rapids, 4½ miles above Lewiston, Idaho, at $38 per cubic yard. This price was at first deemed exorbitant, but after considering the smallness of the appropriation, the remoteness of the rapids and the difficulties of reaching them, and the expense of a plant specially built for the work, it was decided to recommend that the proposal of Mr. Smith be accepted. In October an assistant engineer was sent up the Clearwater to make a careful survey of Reuben's Rapids, and at the same time the contractor sent his working party to Lewiston to commence the building of his drill-scows. Early in November the contractor, with his party and plant, was upon the ground, and the work of drilling was commenced as soon thereafter as the scow could be securely anchored over the site. The large bowlder in mid-channel, 80 feet long and 10 feet wide, upon which so many rafts had been wrecked, was taken in hand first, four gangs of drillers working simultaneously. The drilling progressed very slowly at first, on account of the swiftness of the current making it difficult to keep the scows in place. The contractor did not long remain embarrassed by this condition of affairs, for, within a few days after starting his work, a raft of logs 75



U.S. ENGINEER OFFICE PORTLAND, OREGON
To accompany annual Report June 30th 1880.
G. L. Gillespie
Major of Engineers, Brt. Lt. Col. U. S. A.

feet long by 25 feet wide, whilst endeavoring to pass the rapids, stranded upon the main bowlder without breaking up. The raft for the time being was abandoned by its crew, and the contractor, seeing his opportunity, occupied the wreck for a drilling platform, and was soon enabled to honey comb the bowlder with holes, and subsequently completely destroy it by large blasts without any trouble. The removal of this bowlder, and a few small ones adjacent, was completed by the 1st of December, and shortly afterwards several rafts passed over the rapids without suffering either detention or injury. The contract was closed and the contractor fully paid up on the 8th of December.

There is now a fair channel through the rapids, for rafts or small boats, 60 feet wide, with 4½ feet at low stage, and it will be sufficiently improved for present purposes when a small additional quantity of rock shall have been removed from the reef just above bowlder No. 1, where there is now only about 2 feet at low stage.

By act of Congress approved May, 1880, the sum of $5,000 was appropriated for continuing the improvement; it is probable that this money will be applied in blasting the few remaining bowlders at Reuben's Rapids and in commencing an improvement either at Kent's Chute or at the Big Eddy. This latter rapid is said to be the worst on the Lower Clearwater, and it is probable that some of the existing difficulties to navigation may be removed by blasting out a few isolated bowlders of small areas, which create in mid-channel whirls that are dangerous for the passage of rafts.

In compliance with the act of Congress June 23, 1866, I respectfully state that the following are the appropriations which have been made for this improvement:

Act of March 3, 1879	$5,000
Act of June 14, 1880	5,000

The estimate of amount required for the original project was $34,424.

The Clearwater is in the collection district of the Willamette. The nearest port of entry is Portland, Oreg., at which the revenue collected for the year ending June 1, 1880, was $97,441.82. The nearest military post is that of Fort Lapwai, on Lapwai Creek, a tributary of the Clearwater, 12 miles east of Lewiston, Idaho. The nearest light-houses and works of defense are at the mouth of the Columbia, distant 500 miles approximately.

The timber interest on the Middle and South forks of the Clearwater will be greatly benefited by a continuance of the improvement. The logs which have been brought out from these streams during the past year have largely exceeded the number of previous years, and have been used both for ties for the railroads now building in East Oregon and Washington and Idaho Territories and for lumber and timber to be used in house-building and in the various applications of timber for railroad construction. There is no other commerce on the river within the limits of the projected improvement, and no steamboat enters the river at all from the Snake. Timber is very scarce on the Snake and Lower Clearwater rivers, and it seems quite advisable that the latter stream should be so improved as to enable logs to be brought with facility from the Bitter Root Mountains and its foot-hills at the sources of the river, where this important article of commercial value so extensively abounds.

Abstracts of proposals and contract, and a statement of funds, are transmitted herewith. A chart of Reuben's Rapids accompanies this report for publication.

Money statement.

July 1, 1879, amount available	$5,000 00	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$10,000 00
July 1, 1880, amount expended during fiscal year		5,000 00
July 1, 1880, amount available		5,000 00
Amount (estimated) required for completion of existing project		24,424 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		10,000 00

Abstract of proposals for improving Lower Clearwater River, Idaho, opened by Maj. G. L. Gillespie, Corps of Engineers, September 23, 1879.

Number.	Name and residence of bidder.	130 cubic yards of solid rock, more or less, per cubic yard.	Remarks.
1	Silas R. Smith, Lewiston, Idaho	$38 00	Contract awarded

Abstract of contract for improving the Lower Clearwater River, Idaho, in force during the fiscal year ending June 30, 1880.

Number.	Name and residence of bidder.	Date of contract.	Subject of contract.	Price per cubic yard.	Remarks.
1	Silas R. Smith, Lewiston, Idaho	October 16, 1879	Removal of rock	$38 00	Contract closed December 8, 1879.

CONDENSED HISTORY OF THE IMPROVEMENT OF THE LOWER CLEARWATER RIVER.

An examination of the Lower Clearwater, a tributary of the Snake, from near Mount Idaho to Lewiston, a distance of 84 miles, was made in September and October, 1878.

The South Fork, a mountain stream, with many rocky rapids, was reported impracticable. The main stream is divided by its physical features into two sections, known as the middle and lower rivers. The first 29 miles in length, in addition to its general difficulties of rapid current and rocky bed, presents two points which can only be improved by canals and locks. The latter, 40 miles long, is of the same general character, but more susceptible of improvement; a depth of 4½ feet at low-water being considered obtainable by removing obstructing rocks and bars, at a cost estimated at $34,424.

The Clearwater enters the Snake at Lewiston. It drains a large wheat-producing section in Idaho, which is rapidly filling up by emigration. The present necessity for its improvement is, however, of secondary importance compared with that of the Snake below Lewiston, the principal depot. The examination was authorized by the act of June 18, 1878.

1878–'79.

(Officer in charge, Maj. G. L. Gillespie, Corps of Engineers.)

Amount appropriated by act of March 3, 1879	$5,000
Expended during fiscal year	5,000

October 16, 1879, a contract was made with Silas R. Smith for the removal of 115 cubic yards of rock at Reuben's Rapids, 4½ miles above Lewiston, at $38 per cubic yard. Work was begun early in November and pushed so rapidly that by the 1st of December the principal obstructing rock, and several smaller ones, had been removed, opening a channel 60 feet wide and 4½ feet deep at low stage, affording passage for small boats and rafts. The contractor was paid off, and his contract closed.

M M 8.

EXAMINATION OF COWLITZ RIVER, WASHINGTON TERRITORY.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 15, 1879.

GENERAL: I have the honor to transmit herewith a chart of the Cowlitz River, Washington Territory, together with the report of Mr. R. A. Habersham, assistant engineer, and to submit the following report of an examination made under my direction, in compliance with the river and harbor act of March 3, 1879.

As an examination was particularly asked for the purpose of ascertaining the feasibility of improving the river by removing the snags which obstructed its navigation at various points, I confided the duty to an assistant who has commanded for several years the snag-boat used on the Upper Willamette, and is thoroughly familiar with the cost and difficulties of removing the snags which are usually found in the tributaries of the Columbia River.

The Cowlitz is quite an important little river, and the country it drains is rapidly filling up with a thrifty and industrious population. The two river steamers which do the carrying trade for the river have brought out this year a larger amount of produce than ever before, and it is expected that the yield next year will be still larger. The sum of $5,000 will remove all the important snags which obstruct the navigation of the river as high up as Cowlitz Landing, 40 miles from the mouth, and will provide ample means for surveying in detail all the shoal bars. The improvement indicated in the report of Assistant Engineer Habersham is a very worthy one, and I would recommend that the sum of $5,000 be appropriated for carying it out during the next fiscal year.

The Cowlitz River is partly in the collection district of Oregon and partly in that of Puget Sound, Washington Territory, and the nearest port of entry is Astoria, Oreg., at the mouth of the Columbia River. The revenue collected at that port during the 11 months ending May 31, 1879, was $21,071.31.

Aggregate tonnage of all vessels entered	399,663 tons.
Aggregate tonnage of all vessels cleared	425,063 tons.

The nearest light-houses and works of defense are at the mouth of the Columbia River, Oregon.

The sum of $5,000 can be profitably expended upon this improvement during the next fiscal year.

I am, general, very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Brevet Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 12, 1879.

COLONEL: I have the honor to submit the accompanying map of the Cowlitz River, in Washington Territory, and of the country through which it flows. Its value as a navigable stream, and the necessity for removal of the principal obstructions, will appear from the data given below, obtained by an examination made in pursuance of your letter of instructions of the 15th of November, current year.

The Cowlitz River rises in the heart of the Cascade Mountains, in longitude 121° 50' west, latitude 46° 30' north, on the south watershed of Mount Rainier, flowing due west for 60 miles; then south for 20 miles, and entering the Columbia 60 miles above Astoria, 5 miles below Kalama, the present southern terminus of the Northern Pacific Railroad in Washington Territory, and 48 miles from Portland. It is navigable at its lowest stage, with a least depth of 2½ feet on the bars, to Cowlitz Landing, 40 miles from its mouth; and during higher stages 5 miles farther, 1½ miles above Laton's Ferry. The bar at its mouth has 7 feet depth at low tide. Just above the depth is reduced to 3½ feet by heavy drift in the channel. From the mouth to Black's Bar, the head of the tidal section, a distance of 9 miles, the width of the river averages 500 feet. Above this, to the head of navigation, 250 feet. The bed of the navigable portion of the river is principally composed of large pebbles of volcanic rocks, varying from dense black basalt to pumice, some of the latter so light as to float. The banks are from 5 to 20 feet high, steep, and in some places vertical.

The valley of the Cowlitz is fertile; generally covered with forests of fine timber, principally fir and cedar. There are several fine tracts of prairie land, and numerous rich coal veins, as yet undeveloped. The Northern Pacific Railroad is built along the east or left bank of the river for 20 miles, crossing at the mouth of Pumphrey's Creek. There are two annual seasons of high-water, one occurring during the winter, and caused by rains; the other in June, or July, due to melting of the snows in the Cascade Mountains. The bottom of the girders of the railroad bridge at Pumphrey's is 45½ feet above low-water mark, and 17½ feet above high-water of June, 1876, the highest on record. Steamboats can pass under the bridge when the water is not more than 10 feet above low-water mark.

The most important place on the river is Freeport, formerly Monticello, 3½ miles from its mouth. It has a population of 300, with two stores doing a general merchandise business. There are 55 families residing in and around the town. The population of the Cowlitz Valley has increased 50 per cent. within the last 5 years.

The area under cultivation in the valley along the river banks is 26,000 acres. The exports are lumber, shingles, cattle, hogs, grain, vegetables, and general farm and dairy produce. During the last year 11,000 passengers and 15,000 tons of freight were transported by the two steamboats, which run regularly, making daily trips on the river.

The obstructions to navigation are Black's Bar, Huntington's Bar, Battoe Rapids, Shappelier Rapids, Pumphrey's Bar, Gravel Rapids, and Cluckey's Bar, besides another bar to which no name has been given, and numerous snags and drift-piles at various points, but principally on the bars and rapids. The number of snags to be removed is nearly 300. The sum appropriated for this examination was not sufficient to enable an instrumental survey of the bars to be made. They are in a great measure due to the accumulation of drift-wood, the removal of which would probably cause several of them to disappear altogether, and would certainly produce such changes in the condition of the channel generally as to render necessary a later survey of the bars before projecting any plan for their improvement. At present those interested in the navigation of this stream ask only that the obstructing drift which reduces the available depth of water by one-half be removed. This would occupy the snag-boat three months at a monthly cost for running expenses of $800. Surveys of the bars after removing the drift will cost $600. I am indebted to Capt. Joseph Kellogg, owner of the Cowlitz River steam-

ers, for the information concerning freight and passenger carriage during the last year, and for other statistics.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major, Corps of Engineers, U. S. A.

M M 9.

SURVEY OF UMPQUA RIVER, OREGON, BETWEEN SCOTTSBURG AND ITS MOUTH.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 10, 1879.

GENERAL: I have the honor to transmit herewith a chart of the Umpqua River from Scottsburg to its mouth, including the bar at the entrance, together with the report of Assistant Engineer R. A. Habersham, and to submit the following report of the survey made under my direction in accordance with the requirements of the river and harbor act of March 3, 1879.

The Umpqua River rises in the Cascade Mountains, in longitude 120° west, near Mount Thielsen, and after flowing westward in a tortuous course for 180 miles empties into the Pacific Ocean about 25 miles north of the entrance to Coos Bay, and 175 miles south of the Columbia River.

The examinations made previous to this date, with the view to an improvement of the river, have been confined principally to that portion of the river between Roseburg and Scottsburg; the present survey extends from Scottsburg to the entrance, a distance of 26 miles.

Gardiner City, a small town of 300 inhabitants, 8 miles from the sea, is the head of navigation for sea-going vessels, and Scottsburg, 17 miles higher up, is the head of navigation for river boats. Between these two towns there are no roads or trails, and the people are dependent upon the river for their communication. The commerce of the river is carried in two small river boats, which draw not to exceed 3 feet. Except over the bars at Brandy Island, Echo Island, and mouth of Dean Creek, there is plenty of water at low stage to meet all the necessities of the commerce of the river. The three bars are of recent formation and are composed of sand, mud, and gravel, overlying a sand-rock formation which forms a conspicuous part of the side slopes of the range through which the river makes its way. Umpqua Bay, into which the river empties, is 8 miles long, with an average width of 1 mile; it has a sheltered anchorage of 1,500 acres, with depths ranging from 14 to 30 feet. The shape and general character of the bay are very much the same as at Coos Bay; the north shore is a low sand-spit, covered with drift-wood, whilst the south shore is a high and enduring promontory. The least depth on the bar at low tide is 13 feet, and the distance between the 18-foot curves following the course of the channel is 3,200 feet, with a least width of channel of 300 feet. No special change has occurred in the form and position of the bar since the examination by the Coast Survey in 1852. The main interests of the lower valley center at Gardiner City, which derives its importance from its lumber mills and salmon canneries; but there is a small trade in the upper river, and the object the citizens had in view in applying for the survey was to determine the feasibility of removing the bars and other

obstructions in the river so as to gain an uninterrupted navigation from Scottsburg to the sea throughout the year. The obstructions indicated by Assistant Engineer Habersham are of small importance, and it is recommended that they be removed by the inexpensive means he suggests. No elaborate works of improvement are intended; the increased depth over the bars which the steamboat captains ask can be readily gotten by low dikes made of logs, fascines, stone, and gravel, all of which materials can be readily gotten near the site at very small expense. The rocks in the channel near Scottsburg are four in number and small in capacity, but are so obstructive to navigation that their removal seems clearly called for. The estimated cost of the improvement, as stated in the accompanying report of Assistant Engineer Habersham, to which attention is respectfully invited, is $11,110, and an appropriation for that amout is recommended.

The Umpqua River is in the collection district of Southern Oregon. Gardiner City, at the head of the bay, 8 miles from the bar, is a port of entry. There were no foreign imports, and, consequently, no revenue collected during the past year. The deputy collector reports that about 40 tons of merchandise are brought to the port monthly by the coast traders. The shipments from the port are principally to San Francisco, and consist of lumber, which has amounted to 5,893,000 feet, board measure, from January 1, 1879, to October, 1879. The nearest light-house is at Cape Arago, on the south side of the entrance to Coos Bay, and the nearest works of defense are at the entrance to the Columbia River.

The sum of $12,000 can be profitably expended upon the works of improvement recommended herein during the next fiscal year.

Very respectfully, general, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 6, 1879.

COLONEL: I have the honor to submit the map of the Umpqua River from Scottsburgh to its mouth, showing also in detail the obstructions to navigation, and the following report of the survey of the river, made in compliance with your letter of instructions, dated August 12, 1879.

The Umpqua River rises in the Cascade Mountains, in longitude 122° west, and flows westward for 180 miles, measured along its sinuosities, entering the Pacific Ocean in longitude 123° 50′ west, latitude 43° 40′ north, 175 miles south of the mouth of the Columbia.

Its principal branches are the North and South Umpqua, which unite 96 miles above its mouth. It drains, with its tributaries, an area of 4,200 square miles of mountainous country, a large portion of which is bare of other vegetation than coarse grass. Its bed is rocky, generally rock in position, to within 20 miles of its mouth. Scottsburg, a village of less than 100 inhabitants, situated on the north bank of the river, 26 miles from its mouth, is the head of navigation. Above this the channel presents a succession of rapids and deep pools. In 1871 a small steamer ascended to Roseburg, a distance of 80 miles, during very high water. The trip was an experiment which, proving costly and dangerous, has not been repeated. From Scottsburg to Gardiner, at the head of the Umpqua Bay, a distance of 17 miles, navigation at present is carried on by means of two small steamboats, drawing 2 and 3 feet respectively, which make tri-week'y trips between the two points, carrying the mails, passengers, and freight.

For 6 miles below Scottsburg the river is from 300 to 1,500 feet wide, and from 4 to 19 deep, except at the shoals hereafter to be noticed. Along this section it flows between steep, rugged hills of terraced sandstone, from 500 to 1,000 feet high, whose slopes extend generally in an unbroken line into the water. Here and there a strip

of nearly level land, a few yards wide, exists on the bank, not large enough to be worth cultivating. The margins are fringed with a dense growth of myrtle, wild rose, and salal.

Most of the timber has been destroyed by the forest fires which have devastated so many hundreds of square miles of the coast country, and the little which remains is stunted, fit only for fire-wood, and, from the rugged nature of the ground, difficult to obtain. There is but one inhabited house on this section, and there are only four residents between Scottsburg and the head of the Umpqua Bay. There are no roads nor even trails connecting the houses of the settlers. The only means of communication is by water. Five miles below Scottsburg the river begins to widen. From this point to the head of the bay its width varies from 1,000 to 2,400 feet, while the bases of the hills, receding from its banks, leave several strips of level land, from $\frac{1}{4}$ to $\frac{1}{2}$ a mile in width, and from 3 to 6 feet above mean tide-level. These flats were evidently, at no very distant period, covered by the tides, as shown by their uniformly low elevation, by the identity of the earth of which they are composed with that of the tide marshes in the vicinity of the bay, and by the saline grass which covers the ground along the banks.

All of the arable land on the Umpqua below Scottsburg is contained in these meadows, whose combined areas do not exceed 2,000 acres. They are well adapted to agriculture and grazing, the soil being rich, and the vegetation easily cleared.

Umpqua Bay, from its entrance to its head, is 8 miles long, and from $\frac{3}{4}$ to $\frac{1}{2}$ mile wide. On portions of both sides marshes, intersected by tidal sloughs, extend to the base of the hills. These lands cover about 1,800 acres, which, when reclaimed by diking, will be valuable. The bay is perfectly land-locked, affording a sheltered anchorage of 1,500 acres, with depths ranging from 14 to 30 feet at low-tide.

It is deepest just below Gardiner. The entrance to Umpqua Bay presents the same principal features and general outlines as the Alsea. Rugged hills, covered with fir timber on the south: a long line of sand-spit strewn with drift on the north; the channel running westward to the bar, which lies $\frac{1}{2}$ a mile outside of the general shore line.

No change of importance is perceptible in the form and position of the bar, as shown by the United States Coast Survey of 1852.

By the courtesy of Captain Hill, of the tug Fearless, I was enabled to make soundings across the bar, and found 13 feet least depth at low-tide. The distance between the 18-foot contour lines inside and outside is 3,200 feet, and the width of the channel 300 feet at its narrowest point. Inside, on the south side of the channel, near the second headland, there is a dangerous rock, shown on the map, awash at low-water. On this a small wooden buoy, not easily visible to those unacquainted with its exact position, has been placed. Two buoys are needed, one on the bar, the other inside, near Winchester Head, the promontory on the south side of the entrance. Sailing vessels provided with pilots who know the bar can enter in favorable weather. Generally the outward passage should not be attempted without a tug.

Gardiner City, a town of 300 inhabitants, is situated on the north shore of the bay near its head. It derives its principal importance from its lumber-mills, owned by Messrs. Hinsdale & Co. and Simpson & Co., which furnish employment, directly or indirectly, to its inhabitants and those of the surrounding country, who are generally engaged in the lumber trade; the agricultural lands, lying in small tracts, being as yet undeveloped. These mills have a capacity of 1,000,000 and 700,000 feet, board measure, per month, respectively. The lumber worked is principally fir—spruce, although abundant, being in little demand—and is shipped on sailing vessels to San Francisco.

Two salmon canneries have been established here, one of which has lately been discontinued. The run of salmon is not regular, and the present year, so far, has been too small to be utilized. Smith's River, a stream nearly as large as the Umpqua at its mouth, enters the bay a mile above Gardiner. It is navigable for small steamers for 9 miles above its mouth.

The floods of the Umpqua occur in the winter. The highest recorded is that of December, 1861, which rose to a height of 45 feet above low-water mark at Scottsburg, and covered the marshes in the bay to a depth of 2 feet.

This survey was requested by residents of Scottsburg for the purpose of ascertaining the feasibility and cost of removing the obstructions to navigation between that point and Gardiner. These consist of three bars, existing at Brandy Island, Echo Island, and the mouth of Deane's Creek, and of a number of rocks in the channel just below the steamboat landing at Scottsburg. They are shown in detail on the accompanying map, together with the works considered necessary for their removal.

These bars have all been formed recently, as within a few years schooners drawing $7\frac{1}{2}$ feet ascended to within a mile of Scottsburg. They are composed of sand, mud, and gravel overlying rock, with a ruling depth of $2\frac{1}{2}$ to 3 feet at mean low-tide. The materials required in building jetties to increase the scour are found in abundance in the vicinity. In the absence of a pile-driver, the jetties may be built of fascines and gravel, the latter contained in sacks (a plan successfully employed in building dams on

the Upper Willamette, with cribs filled with stone and riprapped at their extremities.

The estimated cost of improving the three bars is as follows:

At Brandy Island, 800 feet of jetty; at Echo Island, 1,100 feet of jetty; Deane's Creek, 1,200 feet of jetty.

Total length, 3,100 feet at $2.50 per foot	$7,750
3 cribs, 15 by 10 by 5 feet, $500 each	1,500
	9,250
Removal of 85 cubic yards of rock, at $10	850
	10,100
Engineering and contingent expenses, 10 per cent	1,010
Total cost of the work	11,110

The first town of Scottsburg was built one mile below the present one, and was carried away by the disastrous flood of 1861, and afterward built on its present site. It was formerly the principal depot of supplies brought from San Francisco for the mining districts of Southern Oregon. Since the establishment of communication by rail and stage between Portland and San Francisco it has declined, this section of the country being thinly settled.

The soil of the upper portion of the Umpqua Valley is better adapted to grazing than to agriculture; and its products, principally wool and hides, are shipped by rail to Portland. The improvement of the river below Scottsburg would benefit only the local trade, which at present is inconsiderable. At the same time it is advisable to remove the rocks from the vicinity of Scottsburg, as they are dangerous; and if the shoaling on the bars, which has been progressing for several years past, continues, it will be necessary to improve them in order to keep open the only route through this section of the State which is transitable at all seasons of the year.

* * * * * * *

Very respectfully,

ROBERT A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major, Corps of Engineers, U. S. A.

M M 10.

SURVEY OF ALSEA HARBOR, OREGON, AND BAR IN FRONT OF IT.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 3, 1879.

GENERAL: I have the honor to transmit herewith a chart of Alsea Harbor, Oregon, accompanied by the report of Assistant Engineer R. A. Habersham, and to submit the following report of a survey made under my direction in compliance with the river and harbor act approved March 3, 1879.

Maj. J. M. Wilson, Corps of Engineers, states in his report on an examination of this harbor, dated September 23, 1878, that

> The act of June 18, 1878, directed an examination to be made of the "Alsea River and Bay, Oregon," and an estimate of the cost of improvement "proper to be made." The result of the examination and of conversations with residents at the bay demonstrated the fact that no improvement of this river and bay was expected, and none is deemed proper to be made. What the people of the Alsea Valley want, and what I respectfully recommend, is that an accurate survey may be made of the harbor, and the bar in front of it, proper charts prepared for distribution to mariners, and the bar properly buoyed.

No work of improvement is deemed "proper to be made," but I would respectfully recommend that the chart of the harbor be printed for the use of mariners.

There is no port of entry at the Alsea River. The nearest port of entry is at Newport, Yaquina Bay, Oregon, 14 miles north of Alsea Harbor.

No revenue was collected at Newport for the fiscal year ending June 30, 1897. A small coasting tug occasionally enters Alsea Harbor and does some of the carrying trade for the harbor. No sailing vessels ever visit the harbor.

The nearest light-house is on Cape Foulweather, about 18 miles distant; the light formerly located at the entrance to Yaquina Harbor has been discontinued. The nearest works of defense are at the mouth of the Columbia River, distant 125 miles approximately.

I am, general, very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineers,
Brevet Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. R. A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 3, 1879.

COLONEL: I have the honor to submit herewith the chart of Alsea Bar and Harbor, drawn from the survey made in pursuance of your letter of instructions, dated August 12, of the present year.

The bar is situated 125 miles south of the mouth of the Columbia, and 14 miles south of Yaquina Bay. A full description of the bay and the country tributary to it, its resources and products, has been given in the report of your predecessor for the fiscal year ending June 30, 1878.

The portion of the bay included in the survey, referred to as the harbor, comprises all anchorage ground for such vessels as can cross the bar; that is, whose draught does not exceed 12 feet. It covers an area of 60 acres, with a depth of from 10 to 18 feet at low-tide. The tidal range is 3 feet during neap, and 9 feet during spring tides.

The entrance to the harbor lies between a bold headland, 60 feet high, on the south, and a long low sand-pit, covered with drift wood, on the north. It is narrow, being not more than 200 feet between the 12-foot curves, and from 25 to 40 feet deep.

From the entrance towards the bar the channel widens to 400 feet, curving sharply from west to north-northwest, and back to west-northwest, crossing the bar on the last-named course. The bar lies 3,000 feet outside of the general line of the shore at high tide, connecting the south shore and north spit, its axis being nearly parallel with that of the latter. It is 800 yards in length, and 700 yards in width between the curves of 12 feet.

The ship channel shifts constantly from one place to another, a heavy wind, lasting for a few days, being sufficient to cause it to move several hundred feet northward or southward. Generally the southerly weather which prevails during the winter drives it northward, and the northwest winds of summer force it southward. It is rarely found, however, on the south half of the bar, the southerly winds and currents being strongest and prevailing during the greater part of the year. At the time of the survey the channel crossed the bar near its northern extremity, with a width of 300 feet between the 6-foot curves, and a least depth of 7¾ feet at low-water, and I am informed that these dimensions do not change. The distance across the bar, varying with each new direction of the channel, ranges from 1,300 to 1,800 feet.

The steam-launch engaged for this survey failing to arrive, a six-oared boat was the only craft which could be obtained for sounding. In this it was not safe to venture far outside of the bar, for fear of losing the intervals of smooth water necessary to enable us to recross the bar, which occurred very rarely; in fact, only three times during the two weeks I spent in making the survey, and lasting less than an hour on each occasion. It was not possible, therefore, to survey the approaches to the bar; but as no breakers were seen, even in rough weather, outside of those on the beach, it is safe to conclude that the foreshore slopes uniformly, with a tolerably smooth bottom. If the survey could have been made in the month of June or early in July, more complete information could have been obtained.

There are no outlying reefs nearer than the seal rocks, 4 miles north of the bar. These are pinnacles, rising out of the sea to a height of from 10 to 30 feet at low-tide, distant from the shore from one-eighth to one-fourth of mile, and are portions of a ledge of basaltic rock which forms the rugged shore line for an extent of about a mile opposite the rocks. During ordinary weather the bar may be safely crossed by steamers drawing not more than 12 feet at high-tide; sailing craft larger than fishing boats should not attempt to enter without a tug, except with a west wind and tolera-

bly smooth bar, but may cross outward at any time when the wind comes from the east, northeast, or southeast.

The promontory which marks the south side of the entrance to the harbor is formed of coarse soft sandstone, containing fossil shells and hard nodules; and rests, at the level of low tide, on a bed of soft, soapy, black shale, inhabited by myriads of rock oysters. The hills around the bay are similar in formation to the promontory, and are covered with forests of spruce timber from 60 to 100 feet high.

Inside of the entrance the contour of the bottom shows marked changes since the survey of 1875, and the ruling depth is from 2 to 3 feet less. It is possible that in the absence of an established tide-gauge the base assumed for the levels of that survey may have been too high, and the discrepancy in the tide lines of the two surveys at points where the beach, being rock in position, could not have altered in shape, makes this probable. The base adopted for the present survey was the level of mean low spring tides as given in the official tide tables for 1879, from which the daily tidal changes in the bay during the survey did not vary sensibly.

This survey was made between the 17th and 31st of August, rough water and foggy and rainy weather prevailing during the greater portion of the time.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major, Corps of Engineers, U. S. A.

APPENDIX N N.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON AQUEDUCT.

REPORT OF LIEUTENANT-COLONEL THOS. LINCOLN CASEY, CORPS OF ENGINEERS, BVT. COLONEL, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

N N 1.

PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington, D. C., July 21, 1880.

GENERAL: I have the honor to submit the following annual report of operations upon public buildings and grounds for the year ending June 30, 1880:

GROUNDS SOUTH OF THE EXECUTIVE MANSION.

These grounds are being laid out in accordance with a general project for the improvement of the contiguous reservations south of Pennsylvania avenue, as designed by A. T. Downing in 1851–'53. The main feature for this lot is an open elliptical field, covering some 17 acres in the center of the square, the borders of the square to be planted thickly with trees and shrubbery. During the past year very satisfactory progress has been made with this improvement, and the grading, soiling, and seeding of the central ellipse has been completed, excepting a small area in its center, left by reason of an incompleted sewer in charge of the District Commissioners. The large depression along Seventeenth street was filled to grade, mainly from the excavations of the cellar of the north wing of the State, War, and Navy Departments building, and a portion of this surface was soiled and sowed in grass seed. The western half of the 50-foot roadway surrounding the ellipse was finished, and good progress made in the grading of the northeastern portion of the grounds. A thick belt of evergreen trees was planted about the Executive stables, and a number of rapidly growing deciduous trees and shrubs mixed with them, which in a few years will form a screen, shutting off the building from the ornamented grounds.

The total quantities of materials deposited in the lot during the year were as follows: 56,980 cubic yards of earth; 9,053 cubic yards of soil; and 2,228 cubic yards of gravel. During the coming year it is expected to complete the grading, soiling, graveling, and planting of the eastern half of the lot, giving to that portion something of a park-like appearance.

MONUMENT GROUNDS, AND GREENHOUSES AND NURSERY.

These grounds remain in much the same condition as at the close of the last fiscal year. As long as the work of construction of the Washington National Monument is going on a large portion of the surface of the lot must be given up to this work for the storage of stone and other materials, while pathways worn by the workmen and vistors will cover the lawns in every direction. The roadways during the year were carefully attended to, particularly the north roadway, which was regraveled throughout its entire extent. The bare and ungrassed slope bordering it on its south side was plowed up, heavily manured, and sown down with bluegrass and winter rye.

The greenhouses and nursery were kept up to the full standard of excellence. Extensive repairs were made upon the plant-houses, fences, and sewers in the summer of 1879, and the stock of foliage and bedding plants so much increased as to permit of the planting in the spring of 1880 of more than 70,000 plants in the public parks. Many of these plants are of rare and beautiful varieties of foliage. The nursery has been carefully attended to, and has furnished during the year over 2,600 evergreens and deciduous trees for planting in the reservations. The stock in it was increased by some 1,300 trees purchased and set out for acclimation. The plant-houses and nursery are of great benefit and advantage to the public grounds, and should be so extended as to furnish some 200,000 bedding plants and 5,000 trees per year.

SMITHSONIAN GROUNDS.

Until within a few years a special item of appropriation was granted annually to the Smithsonian grounds, its great extent of lawns and roadways requiring large expenditures to keep them in order. As far as the general appropriation for all the reservations, and the heavy teaming and extensive deposit of material for the National Museum building would permit, the grounds and roadways have been kept in good order. At the request of the commission for the construction of the National Museum building, the reconstruction of the grounds around the building was undertaken by this office, and at the close of the year was well advanced towards completion. A want of funds alone prevented their being finished. The foot-walks along the roadways leading east and west from Seventh and Twelfth streets should be asphalted, to accommodate the large number of people either crossing the square or visiting the Museum and Smithsonian Institution for their pleasure or profit. Estimates for this work are inclosed.

ARMORY SQUARE AND RESERVATIONS EAST TO BOTANICAL GARDENS.

These reservations during the year have received their share of attention in the graveling of walks, planting of trees and shrubs, introduction of water pipes, and top-dressing and grading of some of the lawns. They need an extended planting in shrubs and trees and the introduction of a greater number of seats for visitors.

RESERVATIONS NORTH OF PENNSYLVANIA AVENUE AND WEST OF CAPITOL.

Besides the usual attention to these squares, an asphaltum foot-walk was laid in Franklin Square from the Thirteenth and K streets entrance to the Fourteenth and I streets entrance. In Judiciary Square similar

foot-walks were laid along the south sides of E and F streets entirely across the park. In Lafayette Square a number of decaying and unhealthy trees and shrubs were removed, and extensive repairs made upon the grass lawns. A large number of deciduous trees, shrubs, and evergreens were planted, and the foot-walks put in thorough order. The triangular reservation at the intersection of Connecticut avenue, M, and Eighteenth streets was graded, surface soiled, sodded, and inclosed with an iron post and chain fence. In all the improved reservations in this section flower and foliage plant beds were prepared and planted in the spring with choice varieties of plants. In the triangular reservation at Tenth street and New York avenue a fountain appropriate to the size of the grounds was erected.

At the Fourteenth Street Circle the trees and shrubs were removed in November and a stand for the accommodation of the Army of the Cumberland and invited guests was erected preparatory to the unveiling of the statue of Maj. Gen. George H. Thomas. The bronze equestrian statue of this officer was placed in its position upon the pedestal in this circle during November, and unveiled by the Society of the Army of the Cumberland with imposing ceremonies on the 19th of that month. The circle was subsequently rearranged by the planting of deciduous and evergreen plants, and a wire fence was built about it to preserve the lawns from foot-walks and trespasses.

RESERVATIONS EAST OF THE CAPITOL.

These include mainly Lincoln Park and the new park at Stanton Place. The entire regrading and reconstruction of this latter park was commenced in August, 1879, and finished in December of the same year. The park was thoroughly improved in accordance with an approved plan, and the avenues and streets which intersected it and cut up the lawns into small and inferior patches of grass were removed. New grades for its surface, adapting it to the surrounding streets, were established and all the necesary paths and lawns laid out. Water-pipe, gas-pipes, and lamp-posts were introduced, as also two rock-work fountains, and the whole square inclosed with an iron post and chain fence.

A number of the larger reservations in this section of the city should be improved at an early day. Among them, Seward Place, from which the roads and rail tracks should be removed, and the reservations on South and North Carolina avenues, between Fourth and Sixth and Second and Third streets east.

MANURE, SETTEES, FOUNTAINS, IRON FENCES, &C.

During the year compost beds were made, the material of which was applied as a top dressing to the lawns of several of the parks. For the other grassed surfaces 36 tons of Peruvian guano was purchased, which, mixed with rich soil, was applied to the grounds at the rate of 600 pounds to the acre. The beneficial effect of this manure upon the lawns is quite marked.

Besides repairing such settees as are in the parks, 100 new settees were introduced and distributed, 70 of them in the parks west of the Capitol and 30 east of the Capitol.

The fountains received the usual care and protection for the winter, and were placed in thorough order in the spring, the large iron fountain in Georgetown, just across the Rock Creek Bridge, requiring extensive repairs.

All the iron railing and post and chain fences, drinking fountains, and lamp-posts were painted one coat during the fall of 1879 and spring of 1880, and the fences were kept in thorough repair.

BRIDGES.

The bridges in the charge of this office are the Anacostia, Benning's, and Chain Bridges.

At the Anacostia Bridge, during the year, 25,500 feet, board measure, of new pine plank were introduced into the roadway at various times and in small quantities at a time. During the summer of 1879, the roadway and foot-walks of the southwestern approach to this bridge were raised to grade and paved, and the foundations of the keeper's lodge raised to the same level. Twenty-four hundred cubic yards of blue gneiss rip-rap stone were thrown over about the foundations of the piers to protect them from being undermined by the currents. The draw-bridge was carefully attended to, and water barrels placed along the roadway to facilitate the putting out of fires upon the bridge, several of which occurred during the very dry weather of the summer.

At Benning's Bridge extensive repairs were made. All unsound timber and planking were removed and replaced with new material. The old retaining walls of the western abutment, composed of logs, were removed, and replaced with stone masonry laid in cement. The western causeway approach to this bridge was resurfaced with gravel to a depth of a foot, and this roadway put in perfect order.

At the Chain Bridge the iron work was thoroughly painted, and all decayed planks in the roadway removed. A portion of the south retaining-wall of the approach to the bridge on the Virginia side having fallen down, making a gap 35 feet long and 16 feet in height, was rebuilt to a height of 12 feet, being all that could be done with the available appropriation.

EXECUTIVE MANSION.

The necessary repairs to the building and repairs and additions to its furniture have been made during the year. A rose-house was completed for the greenhouses, and the conservatory extended to the western wall of the main building.

Attention is again called to the necessity of paving the approach to the northern front of the building, and an estimate for that purpose is inclosed.

DEPARTMENTAL TELEGRAPH.

The line has been kept in good order during the year, and, as far as the appropriations would admit, the old and rotten poles were replaced with new ones; 46 new 40-foot poles were put in place and painted with two coats of paint. Careful attention was given to the local and main batteries, and crosses after storms were promptly removed. The line has never been in better order.

ESTIMATES OF AMOUNTS REQUIRED FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

Salaries of employés, &c., public buildings and grounds under Chief of Engineers:	
1 clerk	$1,600
1 messenger	840
1 public gardener	1,800
1 foreman and laborers employed on the public grounds	26,000

2 drawkeepers at the Navy Yard and upper bridges, at $720 each....	$1,440	
1 watchman in Franklin Square..................................	660	
1 watchman in Lafayette Square..................................	660	
2 day watchmen in Smithsonian Grounds, at $660 each..............	1,320	
2 night watchmen in Smithsonian Grounds, at $720 each............	1,440	
1 watchman in Judiciary Square..................................	660	
1 watchman in Lincoln Square..................................	660	
1 watchman for Iowa Circle..................................	660	
1 watchman for Fourteenth-street Circle and neighboring reservations..................................	660	
1 watchman for Rawlins Square and Washington Circle.............	660	
1 watchman for McPherson and Farragut Squares..................	660	
1 watchman for Stanton Place and neighboring reservations........	660	
1 bridge-keeper at Chain Bridge..................................	660	
Contingent and incidental expenses Office of Public Buildings and Grounds..................................	500	
		$41,540
Improvement and care of public buildings and grounds in and around Washington:		
For filling in and improving grounds south of Executive Mansion....	15,000	
For ordinary care of greenhouse and nursery......................	1,500	
For ordinary care of Lafayette Square............................	1,000	
For care and improvement of reservation No. 3 (Monument Grounds).	1,000	
For construction and repair of iron fences........................	500	
For manure and hauling the same................................	5,000	
For painting iron fences, vases, lamps, and lamp-posts............	1,500	
For purchase and repair of seats................................	1,000	
For purchase and repair of tools................................	1,000	
For trees, tree-stakes, lime, whitewashing, and stock for nursery....	3,000	
For removing snow and ice................................	1,000	
For flower-pots, twine, baskets, and lycopodium..................	1,000	
For care and construction and repair of fountains in the public grounds.	1,500	
For abating nuisances................................	500	
For improving various reservations..............................	15,000	
For improving Seward Place..................................	5,000	
For improving reservation on South Carolina avenue between Fourth and Sixth streets, east..................................	5,000	
For improving reservation on North Carolina avenue between Second and Third streets, east..................................	4,000	
For improving reservation on New Jersey avenue, northwest........	4,000	
For paving roadways to north front of Executive Mansion..........	8,000	
For ordinary care of Smithsonian Grounds........................	2,000	
For asphaltum foot-walks through Smithsonian Grounds from Seventh to Twelfth streets..................................	1,500	
		79,000
Care of and repairs, fuel, &c., Executive Mansion:		
Care and repairs of Executive Mansion............................	10,000	
Refurnishing Executive Mansion..................................	30,000	
Fuel for the Executive Mansion and the greenhouses................	2,000	
Care and necessary repairs of greenhouses........................	5,500	
		47,500
Care and repair of bridges:		
For ordinary care of Benning's, Anacostia, and Chain Bridges, including fuel, oil, lamps, matches, &c..................................		2,000
Lighting the Executive Mansion and the public grounds:		
For gas, pay of lamp-lighters, gas-fitters, plumbers, plumbing, lamps, lamp-posts, matches, and repairs of all kinds, fuel for office, for watchmen's lodges, and for the greenhouses at the nursery..................		15,000
Repairs of water-pipes and fire-plugs:		
For repairing and extending water-pipes, purchase of apparatus to clean them, and for cleaning the springs, and repairing and renewing the pipes of the same, that supply the Capitol, the Executive Mansion, and the building for State, War, and Navy Departments..................................		2,500
Telegraph to connect the Capitol with the departments and Government Printing Office:		
For care and repair of the same..................................		1,500

Financial statement for fiscal year ending June 30, 1880.

Title of appropriation.	Amounts available at beginning of fiscal year.	Amounts expended and pledged by contracts.
Contingent expenses public buildings and grounds under Chief Engineers.	$500 00	$500 00
Telegraph to connect the Capitol with the Departments and Government Printing Office	1,000 00	1,000 00
Repairs of water-pipes and fire-plugs	2,500 00	2,493 75
Constructing, repairing, and maintaining bridges, District of Columbia	9,200 00	9,172 44
Lighting, &c., Executive Mansion	15,000 00	14,999 33
Salaries of employés public buildings and grounds under Chief Engineer	34,500 00	34,551 77
Repairs, fuel, &c., Executive Mansion	25,000 00	24,998 77
Improvement and care of public grounds	42,500 00	42,071 58

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Lieutenant-Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

N N 2.

WASHINGTON AQUEDUCT.

OFFICE OF WASHINGTON AQUEDUCT,
Georgetown, D. C., July 15, 1880.

GENERAL: I have the honor to submit herewith the annual report upon the Washington Aqueduct for the fiscal year ending June 30, 1880.

The detailed operations upon the Aqueduct during the several months of the year were as follows:

In July, 1879, temporary dams were built in the Potomac River at the upper end of Conn's Island to prevent the water in the Maryland channel from flowing into the Virginia channel. The water had ceased flowing over the Washington Aqueduct dam on June 19, and did not flow over it again until the completion of these temporary dams on July 17. Between Great Falls and Georgetown repairs were made to the macadam road and the conduit embankments.

In August, at Great Falls, *débris* was removed from the Maryland channel of the river immediately above the mouth of the conduit. At the receiving reservoir 576 feet of the roadway was macadamized, the road leading to the gatekeeper's dwelling was repaired, and washes in the slopes of the reservoir dam were filled up. Between the receiving reservoir and the distributing reservoir the embankment slopes and the roadway over the conduit were repaired.

In September, between Great Falls and the distributing reservoir, the conduit road was repaired where necessary, ditches were cleaned out, and washes in the embankments were filled up.

In October, the road from Great Falls to the junction with the conduit road was repaired and three new wooden culverts were built. Between the junction and the receiving reservoir the conduit road was repaired, washes in embankment slopes were filled up, and new telegraph poles were erected in place of old ones. At the receiving reservoir the private

bridge over Powder Mill Branch was repaired, the stone foundations of the old barn were removed, and the old lumber from the barn carefully stored. Between the receiving reservoir and Georgetown the ditches were cleaned out, and the earth excavated was used in filling washes in the embankments. All the bushes and undergrowth on each side of the conduit road from Great Falls to distributing reservoir were cut down and removed.

In November, loose rocks and weeds were removed from the Maryland channel of the Potomac River above the dam. At Rock Creek Bridge the old floor and timbers were removed, they being decayed and worn out, and an entirely new wooden superstructure was built in place.

In December, at Great Falls, the temporary dams above Conn's Island were thoroughly repaired. The river had not flowed over the stone dam since September 20, and the surface of water in the distributing reservoir and in the receiving reservoir had fallen 3 feet below the flow-line. The repairs to the temporary dams were finished on December 8, but the reservoir was not filled to the flow-line until December 15.

College Pond Bridge and Rock Creek Bridge were cleaned and thoroughly painted. At Rock Creek Bridge two of the ornamental scrolls that had dropped off the south arch were replaced and securely fastened with iron bolts.

In January, the conduit road was repaired, and washes in embankments over culverts were filled up. At the distributing reservoir a new copper wire screen was procured and set in the effluent gate house.

In February, culvert No. 23 was found to be nearly filled with gravel and *débris*, and was cleaned out. Between Cabin John Bridge and the receiving reservoir the macadam road and the embankments over culverts 19 and 20 were repaired.

In March, ditches along the conduit road were cleaned out, washes in the embankments were filled up, and the macadam road was repaired. At the high service reservoir, in Georgetown, a part of the iron fence was painted.

In April, at Great Falls, the iron cornice of the gate-house was painted and sanded. The iron-work of the gate-house roof and the doors and woodwork of the gate-keeper's dwelling were painted. Between Great Falls and the distributing reservoir ditches and culverts were cleaned out, washes in embankments were filled up, the macadam road was repaired, and telegraph poles were purchased and erected in place of old ones. The iron cornices of the four ventilators over the conduit were painted and sanded. At the receiving reservoir the doors of the gate-house were painted. At the distributing reservoir the iron-work and the doors of the gate-houses were painted, and the iron cornices of the gate-houses were painted and sanded.

In Georgetown the painting of the iron fence at the high service reservoir was finished. In Aqueduct street the old covers to the pipe-vaults were removed, and new ones were set in place. At Rock Creek Bridge the doors of the engine-room and of the workshop were painted, and a new platform was built between the workshop and bridge abutment.

In May, at Great Falls, the fence around the government grounds was lime-washed. Between Great Falls and Georgetown, 45 new telegraph poles were erected. At the receiving reservoir the roof of the gate-house was repaired, the old plastering was scraped off, new slates were set, and the dome was replastered with Portland cement mortar. The force pump that supplied the gate-keeper's dwelling with water being

worn out, a hydraulic ram was purchased and set in connection with the pipe leading from the spring, and put in successful operation.

Between the receiving reservoir and the distributing reservoir washes were filled in embankments and repairs were made to the macadam road. At the distributing reservoir the fence inclosing the government grounds, being decayed, was removed, and a new fence was built in its place. The picket fence surrounding this reservoir was lime-washed. At Foundry Branch the stone covering of the pipe line was repaired.

In June, at Great Falls, the lime-washing of fences was finished. A part of the back filling of the Potomac dam, which had been carried over the dam during freshets, was replaced.

At the receiving reservoir the fences and out-buildings were lime-washed, and the grass was cut from the connecting conduit and the inner slope of the reservoir dam.

At the distributing reservoir the lime-washing of fences was finished, the inside walls of each gate-house were lime-washed, and the roofs of the influent and effluent gate houses were plastered with Portland cement mortar. The roof and walls of the stair well-house were also plastered with Portland cement mortar. In Georgetown the fence at the high service reservoir, the fences at Rock Creek Bridge, the basement of the office, and the engine room in the bridge abutment were lime-washed. From Great Falls to Georgetown repairs were made to the conduit road where necessary, the ditches were cleaned out, embankment slopes were repaired, and 500 cubic yards of macadam stone were purchased and partly spread.

During the year the machinery in the gate-houses at Great Falls receiving reservoir and distributing reservoir—also in the pipe-vaults at Foundry Branch, Rock Creek, and in Washington—was often cleaned and oiled and kept in good working order. The government mains were regularly flushed, and the general distribution of Potomac water in the conduits, reservoirs, and mains was properly attended to. The government lands at Great Falls, receiving reservoir, distributing reservoir, high service reservoir, and Rock Creek were kept in good order.

The following is a financial statement for the fiscal year ending June 30, 1880:

ACT OF MARCH 3, 1879.

For engineering, maintenance, and general repairs:

Available July 1, 1879	$20,000 00
Expended during fiscal year ending June 30	18,890 13
On hand June 30, 1880	1,109 87

The estimates of appropriations for the fiscal year ending June 30, 1882, are as follows:

For engineering, maintenance, and general repairs	$20,000 00
For commencing the construction of the dam at Great Falls across the Virginia channel of the Potomac	50,000 00
For improving grounds around gate-keeper's dwelling at the receiving reservoir	1,000 00
For building wooden fence around the government land at the receiving reservoir	7,000 00
For soiling, sodding, and seeding the embankment and excavation slopes of the distributing reservoir and conduit	15,000 00
For building a wrought-iron and masonry bridge over the waste-channel at the receiving reservoir	11,000 00
For building an overfall over the connecting conduit for the waste-channel of the receiving reservoir	2,000 00
For continuing the macadamizing of the conduit road	10,000 00
Total	116,000 00

The estimated cost of fully completing the Potomac Dam is $200,000. The present dam which is built across the Maryland channel of the river was finished to its present height in December, 1867. By referring to previous reports it will be seen that each year Congress has been asked for an appropriation to continue its construction across the main channel of the river to the Virginia shore.

The necessity of completing it is sufficiently obvious, for the reason that the consumption of Potomac water in the District of Columbia has for several years been greater than the minimum flow of the Maryland channel. The deficiency has been supplied from the water stored in the receiving and distributing reservoirs. Last year the surface of the water in these reservoirs was lowered, until by the early part of December it was 3 feet below the flow-line, and during October and November the daily consumption of Potomac water, was from 1,000,000 to 3,000,000 gallons greater than the quantity supplied by the Maryland channel of the river.

Temporary dams made of clay, gravel, and brush were built in the river above Conn's Island, to prevent the water in the Maryland channel from flowing into the Virginia channel. There were three of these temporary dams with an aggregate length of 700 feet. They are more or less injured by every freshet, and require very careful attention to keep them from going to pieces. The following table shows the days of the year the water was below the top of the dam at Great Falls, and also the level of the water below the top of the dam:

Table showing the days on which the surface of water in the Potomac River at Great Falls was below the crest of the dam, from July 1, 1879, to July 1, 1880.

[The depths from the crest of the dam to the surface of the water are given in inches and tenths of an inch.]

Months.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1879.											
July	5.6	6.2	6.8	7.2	7.3	4.5	5.1	2.2	1.2	1.0	1.3
August					0.2		0.2				
September						0.2			0.2	0.5	0.5
October	4.0	5.5	5.0	4.5	5.0	5.0	4.0	5.0	5.0	4.5	4.5
November	10.0	11.0	10.0	9.5	12.4	13.6	10.6	10.7	5.2	9.3	7.6
December	7.0	7.0	4.0	4.0	4.3	2.5					
1880.											
January											
February											
March											
April											
May											
June											1.0

Months.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
1879.											
July	1.2	1.2	1.0	1.3	1.2				0.3	1.2	2.3
August				0.2							
September	0.7	2.0	2.0							0.5	1.0
October	4.5	5.0	5.0	6.2	6.5	6.5	7.5	9.0	9.5	11.0	8.0
November	7.3	7.0	7.0	6.5	6.8	9.0	9.5	7.0	8.7	7.3	12.3
December											
1880.											
January											
February											
March											
April											
May											
June	2.0	3.0	0.5								

Table showing the days on which the surface of water in the Potomac River at Great Falls was below the crest of the dam, &c.—Continued.

Months.	23.	24.	25.	26.	27.	28.	29.	30.	31.	Total days.
1879.										
July	3.4	4.0	......	......	......	......	......	......	......	21
August	......	......	......	......	......	......	......	......	......	3
September	1.5	4.5	5.0	5.0	3.5	3.0	5.5	3.0	......	17
October	5.3	4.0	5.0	4.5	5.0	5.0	8.0	9.4	9.5	31
November	11.4	6.0	10.0	10.8	10.7	10.5	7.2	8.5	......	30
December	......	......	......	......	......	......	......	......	......	6
1880.										
January	......	......	......	......	......	......	......	......	......	......
February	......	......	......	......	......	......	......	......	......	......
March	......	......	......	......	......	......	......	......	......	......
April	......	......	......	......	......	......	......	......	......	......
May	......	......	......	......	......	......	......	......	......	......
June	......	......	......	......	......	......	......	......	......	4
Total	......	......	......	......	......	......	......	......	......	112

The conduit road is macadamized from the distributing reservoir to culvert No. 6, a distance of 9 miles; the remainder of the road, some 3 miles, should also be macadamized to facilitate communication along the line of the aqueduct.

The embankment and excavation slopes of the conduit and pipe-line, and the embankment-slopes of the distributing reservoir, should be protected with sods or soiled, and seeded with grass.

The government land at the receiving reservoir should be inclosed with a substantial wooden fence, and the grounds surrounding the gate-keeper's dwelling should be improved by grading and tree-planting.

A stone overfall should be built over the connecting conduit, across the waste-channel of the receiving reservoir, for the passage of water during freshets.

The wooden bridge over the waste channel at the receiving reservoir was built in 1863; its timbers are decayed, and the bridge is fast lapsing into a dangerous condition. It should be removed and a wrought-iron truss-bridge, with abutments of masonry, erected in its place.

Observations of the comparative clearness of the water at Great Falls, the receiving reservoir, and the distributing reservoir were taken and recorded daily. The results are shown in the following table:

Name of source.	Number of days that the water was—			
	Clear.	Slightly turbid.	Turbid.	Very turbid.
Great Falls	188	44	40	94
Receiving reservoir	251	28	41	46
Distributing reservoir	290	27	31	18

The iron mains have been supplied with water directly from the distributing reservoir, and the condition of the water delivered in Georgetown and Washington has consequently been similar to that in this reservoir.

On June 28 the conduit was shut off from the distributing reservoir for 24 consecutive hours, for the purpose of ascertaining the quantity of Potomac water taken from the reservoir by the iron mains. The

elevation of the water surface of the reservoir was recorded each hour, and the quantity of water taken from the reservoir was as follows:

	Gallons.
From 6 hours a. m. to 9 hours a. m	3,219,354
From 9 hours a. m. to 12 hours m	3,633,971
From 12 hours m. to 3 hours p. m	3,628,354
From 3 hours p. m. to 6 hours p. m	3,483,458
From 6 hours p. m. to 9 hours p. m	2,922,099
From 9 hours p. m. to midnight	3,027,448
From midnight to 3 hours a. m	2,914,620
From 3 hours a. m. to 6 hours a. m	2,910,834
Total	25,740,138

The quantity of water taken from the distributing reservoir daily, is		25,740,138
Estimated quantity lost by evaporation is	233,600	
The quantity flowing from the air vents of College Pond Bridge and Rock Creek bridge is	35,000	
The quantity used by the general government is	2,626,188	
		2,894,788
The remainder		22,845,350

is the average quantity used daily by the inhabitants of the District of Columbia.

For a series of years the average daily outflow of Potomac water from the distributing reservoir has been as follows:

	Gallons.
1874	17,554,848
1875	21,000,000
1876	24,177,797
1877	23,252,932
1878	24,885,945
1879	25,947,642
1880	25,740,138

The consumption of Potomac water has now reached about the maximum quantity that can be supplied by the existing system of iron mains.

In July, 1879, I directed the assistant engineer of the Washington Aqueduct to visit all the buildings and establishments of the United States in the District of Columbia, to make a complete list and memorandum of the manner in which they were supplied with Potomac water from the Washington Aqueduct, and to ascertain the quantity of Potomac water used daily in the buildings occupied by the United States Government, and in the public parks.

The results of his observations and measurements show that the average quantity used by the general government at that time was as follows:

	Gallons.
Public buildings	884,094
Public fountains	1,239,646
Public drinking fountains	131,040
Public parks	371,408
Total	2,626,188

A copy of his report, marked A, is appended to this paper.

Under a resolution of the United States Senate of June 6, 1879, authorizing the Senate Committee on the District of Columbia to sit during the recess of Congress to investigate the best means of securing to the cities of Washington and Georgetown an ample supply of pure water, &c., I was called upon by the chairman of the Senate committee to furnish to the committee such information upon the points to which inquiry was directed as was to be obtained from the records of this office.

I inclose, marked B, a copy of the chairman's letter with a copy of the Senate resolution, and a copy of the report made by me thereon.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Lieutenant-Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers.

A.

REPORT OF MR. THEODORE B. SAMO, ASSISTANT ENGINEER.

OFFICE OF WASHINGTON AQUEDUCT,
Georgetown, D. C., October 11, 1879.

SIR: I have the honor to acknowledge the receipt of your letter dated July 30, 1879, in which I am directed to visit all the buildings and establishments of the United States in the District of Columbia, and make a complete list and memorandum of the manner in which they are supplied with Potomac water from the Washington Aqueduct.

In reply I have to state that, in compliance with your instructions, I have recently visited all the buildings and establishments mentioned in the accompanying paper, and collected such information in regard to the water supply thereof as was obtainable. I have also made an approximate estimate of the quantity of Potomac water used daily in the buildings occupied by the United States Government and in the public parks.

In nearly every building occupied by the government I found that strict economy in the use of Potomac water was enjoined, and that the water fixtures generally were in such a condition as to prevent unnecessary waste.

To ascertain the quantity of water used daily, I made a list of the various outlets for water in each building, and allowed for each outlet a quantity which, in my opinion, is greater than the actual quantity used.

To ascertain the quantity used in the public grounds, I measured the flow of water from the outlets, assumed a quantity greater than the average, and multiplied it by the number of hours the water is permitted to flow, on an average, daily.

The estimates of the quantity of water flowing from the public fountains were made from the measurement of the actual quantity flowing from each fountain when under full pressure.

The accompanying paper contains a brief description of the manner each establishment receives its supply of Potomac water, together with an estimate of the daily quantity of water flowing from the public fountains and from the public drinking fountains.

This paper also contains an estimate of the average quantity used daily in the public buildings, and an estimate of the average quantity used daily in the public parks.

An abstract of these estimates is as follows:

		Gallons.
Public buildings		884, 094
Public fountains		1, 239, 646
Public drinking fountains		131, 040
Public parks		48, 960
Monument lakes and fish-ponds		322, 448
Total quantity used daily		2, 626, 188
The quantity of water taken from the distributing reservoir daily is		25, 997, 832
The quantity lost by evaporation is	233, 600	
The quantity flowing from the air-vents of College Pond Bridge and Rock Creek Bridge is	35, 000	
		268, 600
The remainder		25, 729, 232

is used in the District of Columbia, and of this quantity the inhabitants use 23,103,044 gallons.

The quantity used daily by the general government, 2,626,188 gallons, might be reduced by discontinuing the use of Potomac water for motive power in several of the departments; especially in the Treasury Department, where a turbine is used 5½ hours

daily, and an elevator is run by hydraulic pressure; also in the building occupied by the Public Printer, where two condensing engines are in use.

Very respectfully, your obedient servant,

THEODORE B. SAMO,
Assistant Engineer.

Lieut. Col. THOMAS LINCOLN CASEY,
Corps of Engineers, U. S. A.

INCLOSURE TO REPORT OF MR. THEODORE B. SAMO, ASSISTANT ENGINEER.

Columbia Institution for Deaf and Dumb.—Receives its supply of Potomac water through a pipe 3 inches in diameter, which connects with the District main corner of Third and K streets northeast. This 3-inch pipe enters the grounds of the institution and supplies 25 water-closets, 9 urinals, 4 hydrants, 6 sinks, and 5 bath-tubs. The quantity of water used daily is estimated at 18,300 gallons.

Jail of the District of Columbia.—Receives its supply of Potomac water from a 6-inch main in Nineteenth street east by a pipe 4 inches in diameter. The first floor is supplied by gravity, and the second floor by pumping. On the first floor there are 3 water-closets, 5 bath-tubs, 3 urinals, 1 hydrant, 1 wash-basin, 4 washing-machines, and 4 steam-boilers for pumping, heating, cooking, and washing. On the second floor are 2 water-closets, 4 wash-basins, 3 bath-tubs, and 1 sink. The quantity of water used daily is estimated at 18,400 gallons.

United States Navy-Yard.—The navy yard is supplied with Potomac water by the United States 12-inch main. The officers' quarters and the barracks are supplied by a ¾-inch pipe. There are 18 steam-boilers, which are supplied when in use from a hydrant in the yard. There are 66 water-closets, which are supplied by a ¾-inch pipe. The yard-bell is rung for 20 minutes each day by a water-pressure engine. A small fish-pond, in front of the commandant's quarters, is supplied by a ¾-inch pipe. The quantity of water used daily is estimated at 63,200 gallons.

Marine Barracks.—The supply of Potomac water is taken from the United States 12-inch main in Eighth street east by a pipe 4 inches in diameter, which, after entering the yard, branches to the north and south and supplies 2 fire-plugs. Three hydrants are supplied with a pipe 1 inch in diameter. A ¾-inch branch supplies 4 water-closets, and a ½ inch branch supplies a sink. A pipe 1 inch in diameter supplies a bath-room. The daily quantity consumed is estimated at 16,250 gallons.

Washington Arsenal.—The grounds and buildings receive their supply of Potomac water from the United States 12-inch main in Four-and-a-half street. This main, after entering the yard, follows the line of Four-and-a-half street, produced, to the site of the old penitentiary. There it is reduced to 8 inches in diameter, and is continued to the Arsenal wharf. From where it enters the grounds to the wharf there are 21 taps, 9 of which are 1 inch, 10 1¼ inches, and 2 1½ inches in diameter. A large fish-pond is supplied by a pipe 1¼ inches in diameter. The quantity of water consumed daily is estimated at 28,000 gallons.

The Capitol.—The "House Extension."—Receives a supply of Potomac water from a pipe 6 inches in diameter. The basement floor is supplied by gravity through a branch pipe 2½ inches in diameter. The principal floor and the gallery floor are supplied by pumping. There are 2 small pumps, which are supplied by a branch 3 inches in diameter. The water is pumped into tanks in the loft which contain, when full, 21,000 gallons. These tanks are filled three times a week, requiring 16 hours of pumping. The average daily consumption of water is estimated at 25,000 gallons. There are 35 water-closets and 16 bath-rooms.

The central building receives its supply of Potomac water from the 6-inch pipe which supplies the "House Extension," by a pipe 4 inches in diameter. The basement floor is supplied by gravity through 8 one-inch taps, which supply 3 water-closets, 1 hydrant, and 12 wash-basins. There are also, outside of the building, 3 water-closets, which are supplied from a 3-inch pipe in the west grounds by a pipe ¾ inch in diameter. The principal floor including the library and the Supreme Court room, receive their supply from the "House Extension" tanks. The average daily consumption of Potomac water is estimated at 4,400 gallons.

The "Senate Extension" receives its supply of Potomac water from the 12-inch main on the east front of the Capitol, by a pipe 4 inches in diameter. The basement floors are supplied during the recess of Congress by gravity. During the session they are supplied at night by gravity, and in the daytime by pumping. The principal and attic floors are supplied by pumping. There are 5 water-closets and 21 wash-basins on the basement floor, 4 water-closets, 27 wash-basins, and 3 hydrants on the principal floor, and 5 closets, 24 basins, and 3 hydrants on the attic floor. There are 2 small pumps which raise the water into 3 tanks, which contain when full 13,000 gallons.

During the recess, the daily consumption is 4,300 gallons; during the session, it is 8,000 gallons. The average daily consumption is estimated as follows:

	Gallons.
Principal and attic floors	8,000
Basement floor	4,000
Total	12,000

Summary:	
House Extension	25,000
Senate Extension	12,000
Central building	4,400
Total	41,400

United States Coast Survey Building.—The building occupied by the Coast Survey Bureau receives its supply of Potomac water from the 6-inch main in New Jersey avenue by a pipe 2 inches in diameter; 7 floors are supplied by gravity, and 1 floor by pumping. In the building there are 9 water-closets, 6 urinals, 8 sinks, and seven wash-basins. The quantity of water used daily is estimated at 6,675 gallons.

The City Hall.—This building receives its supply of Potomac water from the United States 12-inch main in Four-and-a-half street. There are 14 water-closets, 7 urinals, and 6 wash-basins. The estimated quantity of water used daily is 8,300 gallons. Water does not flow on the main floor when it is flowing in the basement.

Office of Public Printer.—The building receives its supply of Potomac water from the United States 30-inch main in New Jersey avenue, and from a 6-inch main in H street by two pipes each 4 inches in diameter. In the building there are 44 water-closets, 8 urinals, 38 wash-basins, 2 engines, and 2 boilers. The average daily consumption of Potomac water is estimated at 74,840 gallons.

Post-Office Department.—The building receives its supply of Potomac water from the United States 12-inch main in Eighth street by a pipe 4 inches in diameter, which extends around the entire building. There is a fish-trap near where the 4-inch pipe enters the building, which is flushed once a week. The building is heated by a hot-water apparatus which has to be filled once in a year. It has an automatic feed to supply loss from waste and evaporation. There is 1 steam-boiler used for ventilation and power; there are 50 water-closets, self-acting, 12 patent closets, 20 urinals, 120 wash-basins and 17 sinks. The quantity of water used daily is estimated at 29,200 gallons.

Building 915 E street.—This building is occupied by the Post-Office Department, and receives its supply of Potomac water from a 6-inch main in E street. It contains 3 water-closets, 1 urinal, 9 wash-basins, and 1 hydrant. The estimated quantity of water used daily is 3,500 gallons.

Department of the Interior.—The building receives its supply of Potomac water from the United States 12-inch main in F street by a pipe 5 inches in diameter, and from the 6-inch main in Ninth street by 2 pipes, one 4 inches in diameter and one 6 inches in diameter. The entire building, except the model rooms, is supplied by gravity; the model rooms are supplied by pumping. The department also occupies the building on the corner of Eighth and G streets northwest, and the building on the corner of Pennsylvania avenue and Thirteenth street northwest. There are 43 water-closets, 11 urinals, 12 hydrants, 127 wash-basins, 8 boilers, and 2 fountains. The quantity of water consumed daily is estimated as follows:

	Gallons.
Interior Department building	55,300
Pennsylvania avenue and Thirteenth street	4,000
Eighth and G streets	4,000

Pension Bureau.—The building occupied by the Pension Bureau receives its supply of Potomac water from a 6-inch main in Twelfth street by a pipe 6 inches in diameter; 4 floors are supplied by gravity, and the 5th and 6th floors by pumping. There are 26 water-closets, 9 urinals, and 15 basins. The estimated quantity of water used daily is 15,400 gallons.

Army Medical Museum.—The building receives its supply of Potomac water from a 6-inch main in Tenth street by a pipe 3 inches in diameter. In the building there are 12 water-closets, 11 sinks, 11 wash-basins, and 2 urinals. There is also a 2½-inch branch connected with the 3 inch-pipe, but it is only used in case of fires. The quantity of water used daily is estimated at 8,850 gallons.

Department of Agriculture.—The buildings and grounds receive their supply of Potomac water from the 6-inch mains in B street north and B street south, through pipes 6 and 4 inches in diameter respectively. In the grounds, a 2-inch branch from the 6-inch pipe supplies a lake, and another 2-inch branch supplies 2 fountains. From the 4-inch pipe a 2-inch branch supplies the greenhouses. A ¾-inch pipe supplies the

stables. There are also 6 pavement-washers and 1 hydrant. In the building there are 10 water-closets, 31 wash-basins, 6 urinals, 3 hydrants, and 3 fire-plugs. The estimated quantity of water used daily is 22,700 gallons.

Smithsonian Institution.—The building receives its supply of Potomac water from the United States 20-inch main in B street south, by a pipe 6 inches in diameter. In the building there are 10 water-closets, 6 urinals, and 29 basins. The quantity of Potomac water used daily is estimated at 7,000 gallons.

Quartermaster-General's Office.—Receives supply of Potomac water from 12-inch main in Pennsylvania avenue by 3 pipes, 4 inches, 2 inches, and ¾ inch in diameter respectively. The first and second floors are supplied by gravity; the third and fourth floors by pumping. In the building there are 24 water-closets, 40 wash-basins, 9 urinals, and 8 sinks. The quantity of water used daily is estimated at 17,300 gallons.

Bureau of Statistics.—Receives supply of Potomac water from 6-inch main in Fifteenth street by a pipe 1¼ inches in diameter. There are 3 water-closets, 1 urinal, and 7 wash-basins, and the quantity of water used daily is estimated at 2,300 gallons.

Treasury Department.—The building receives its supply of Potomac water from the United States 12-inch main in Pennsylvania avenue by 3 pipes, 2 of which are 6 inches and one 10 inches in diameter. The basement is supplied by gravity, and the rest of the building by pumping. In the building there are 127 water-closets, 250 wash-basins, and 30 urinals. The daily quantity of water used in the building has been estimated from the quantity pumped into the tanks, and is 91,800 gallons. There is in the basement a 16-inch turbine which runs a canceling machine; it is used 5¼ hours daily, and the estimated quantity of water used is 211,159 gallons. In the cash room there is an elevator run by hydraulic pressure; the water is supplied from the tanks and the quantity used is included in the above estimate.

Macerator building and machine-shop.—These buildings are supplied with Potomac water from a 6-inch main in Fifteenth street by a pipe 3 inches in diameter, from which a 2-inch branch supplies the macerator. The quantity used daily is estimated at 1,900 gallons.

The machine-shop is supplied by a 2-inch branch. There are 4 basins and 4 water-closets; each has a ⅝-inch tap. In the laundry there are 2 ¾-inch taps which flow 6 hours daily, and, by measurement, 15 gallons a minute. In the ink-mill there are 3 wash-basins, ⅝-inch tap each. The quantity of water used daily is estimated at 6,950 gallons.

Photographer's Building.—This building receives supply of Potomac water from a 6-inch main in Fifteenth street. There are 4 basins, each with ½-inch tap, and 1 water-closet. The quantity of water used daily is estimated at 4,020 gallons.

Executive Mansion.—The building receives its supply of Potomac water from the 12-inch main in Pennsylvania avenue by a pipe 6 inches in diameter. There are 9 water-closets and 20 ⅝-inch faucets. The quantity of water used daily is estimated at 6,650 gallons.

Department of State.—The building receives its supply of Potomac water from the Seventeenth street main by a pipe 6 inches diameter which extends the entire length of the building. There are 3 branch pipes, each 4 inches in diameter, 1 supplies a pump in the center of the building, and 1 at each end of the building supplies the water-closets. The sub-basement, basement, and first floor are supplied by gravity; the second, third, and fourth floors are supplied by pumping. There are in the building 46 water-closets, 30 urinals, and 25 basins. The quantity of water used daily is estimated at 28,500 gallons.

War Department.—The building receives its supply of Potomac water from the 12-inch main in Executive avenue, by a pipe 8 inches in diameter, which is reduced to 6 inches in diameter in the sub-basement. The sub-basement and first floor are supplied by gravity; the second, third, and fourth floors are supplied by pumping. There are 25 water-closets, 18 urinals, 9 wash-basins, 1 bath-tub, and 5 wash-sinks. The quantity of water used daily is estimated at 18,700 gallons.

Navy Department.—That portion of the building occupied by the Navy Department receives its supply of Potomac water from the 12-inch main in Executive avenue by a pipe 8 inches in diameter; three floors are supplied by gravity and three floors by pumping. There are 24 water-closets, 18 urinals, and 12 basins. The quantity of water used daily is estimated at 16,000 gallons.

Old building.—This building, formerly occupied by the Navy Department, receives a supply of Potomac water from a 6-inch pipe in Seventeenth street by a pipe 4 inches in diameter. The first and second floors are supplied by gravity; the remainder of the building, by pumping. There are 12 water-closets, 8 urinals, 1 sink, 1 bath-tub, and 4 wash-basins. The quantity of Potomac water used daily is estimated at 9,200 gallons.

Wooden building.—This building contains 1 water-closet, 1 urinal, and 1 basin, and the quantity of Potomac water used daily is estimated at 1,200 gallons.

"*Winder's" buildings.*—These buildings receive Potomac water from the 6-inch main in F and Seventeenth streets. The first and second stories are supplied by gravity, the third and fourth stories by pumping. There are 16 water-closets, 16 urinals, and

4 sinks in the main building; in the Ordnance annex there are 8 closets, 2 urinals, and 1 sink. The quantity of Potomac water used daily is estimated at 10,800 gallons.

Buildings occupied by Adjutant-General, Nos. 612, 616, 618, and 620 Seventeenth street, and Thompson's building, on Seventeenth street between H street and Pennsylvania avenue. In these buildings there are 10 water-closets, 5 urinals, and 13 basins. The quantity of Potomac water used daily is estimated at 6,800 gallons.

Signal Bureau.—The Signal Bureau occupies buildings Nos. 1719, 1721, and 1725 G street. They are supplied with Potomac water from the 6-inch main in G street by 3 pipes, each 1 inch in diameter. There are 4 water-closets, 1 urinal, and 8 wash-basins. The quantity of Potomac water used daily is estimated at 2,900 gallons.

National Observatory.—The buildings receive a supply of Potomac water from the United States 12-inch main in Twenty-first street. There are 3 water-closets, 2 urinals, and a small turbine. In the grounds there are 2 hydrants. The turbine is used on clear nights for revolving a telescope. The quantity of water used daily is estimated at 6,300 gallons.

United States Civil Engineer's Office, No. 1907 Pennsylvania avenue.—Receives a supply of Potomac water from the 12-inch main in Pennsylvania avenue by a pipe ¾ inch in diameter. There is 1 water-closet and 1 hydrant, and the quantity of water used daily is estimated at 600 gallons.

Columbia Hospital.—Receives its supply of Potomac water from the 6-inch main in L street by a pipe 1¼ inches in diameter. In the building the branches are ¾ of an inch in diameter and supply 4 floors. There are 10 water-closets, 1 urinal, 7 wash-basins, 5 bath-tubs, 8 sinks, and 4 tubs. The quantity of water used daily is estimated at 12,600 gallons.

Washington Aqueduct Office, Aqueduct street, Georgetown.—Receives its supply of Potomac water from the United States 30-inch main in Aqueduct street by a pipe 2 inches in diameter. There are 2 water-closets and 1 wash-basin. The quantity of water used daily is estimated at 1,100 gallons. In the machine-shop annex there is a turbine wheel for driving machinery; for the past two years it has been seldom used.

Georgetown custom-house.—Receives its supply of Potomac water from a 4-inch main in Congress street by a pipe 1 inch in diameter. There are 3 water-closets, 1 urinal, and 3 wash-basins. The quantity of water used daily is estimated at 1,900 gallons.

PUBLIC PARKS.

The greenhouses and nursery receive their supply of Potomac water from a 6-inch main in B street, southwest, by a pipe 3 inches in diameter. The branches that supply the greenhouses are 1 inch in diameter. On these branches there are 10 ¾-inch faucets. In the nursery the water is taken from a 2-inch globe-valve. The quantity used daily in the greenhouses and nursery is estmated at 2,800 gallons.

Monument Grounds.—The supply of Potomac water is taken from a 4-inch main in Fourteenth street, by a pipe 4 inches in diameter. The branch pipes are 2 inches in diameter. The quantity of water used daily is estimated at 1,800 gallons. The lakes in the Monument Grounds are supplied through a 2-inch jet. The daily discharge of the jet is estimated at 308,448 gallons, which flows into the east lake. The west lake and ponds are supplied by 7 pipes, each 2 inches in diameter. The quantity of water used daily is estimated at 14,000 gallons.

Smithsonian Grounds.—The supply of Potomac water is received from the 20-inch main in B street, southwest, by a pipe 12 inches in diameter. There are four 6-inch branches, and the water is discharged through 2-inch globe-valves. The quantity of water used daily is estimated at 2,160 gallons.

Armory Park.—The supply of Potomac water is taken from a 4-inch main in Seventh street, though a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 1,080 gallons.

Reservation, Maine avenue, between Four-and-a-half and Sixth streets, southwest.—The supply of Potomac water is taken from the 20-inch main in Maine avenue, by a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 540 gallons.

Reservation, Missouri avenue, between Third and Four-and-a-half streets, southwest, receives its supply of Potomac water from a 4-inch main in Missouri avenue, by a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 1,080 gallons.

Judiciary Park.—The supply of Potomac water is taken from a 6-inch main in Fifth street, through three pipes 4 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 4,320 gallons.

Franklin Park.—The supply of Potomac water is taken from a 6-inch main in I street, through a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 5,040 gallons.

La Fayette Park receives supply of Potomac water from the 12-inch main in Penn-

sylvania avenue, through a pipe 3 inches in diameter. The branches are 2 inches in diameter, and the quantity of water used daily is estimated at 3,600 gallons.

Circle at Pennsylvania avenue and Twenty-fourth street, northwest.—The supply of Potomac water is taken from the 12-inch main in Pennsylvania avenue, by a pipe 2 inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Reservation, Pennsylvania avenue and Twenty-first street, northwest.—The supply of Potomac water is taken from the 6-inch main in I street, by a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Reservation, Pennsylvania avenue and Nineteenth street, northwest.—The supply of Potomac water is taken from the 6-inch main in I street, through a pipe 1¼ inches in diameter, with branches 1¼ inches in diameter. The quantity of water used daily is estimated at 540 gallons.

Reservation, Pennsylvania avenue and Eighteenth street, northwest.—The supply of Potomac water is taken from the 6-inch main in H street, through a pipe 1¼ inches in diameter, with branches 1¼ inches in diameter. The quantity of water used daily is estimated at 540 gallons.

Reservation, Pennsylvania avenue and Ninth street, northwest.—The supply of water is taken from the 6-inch main in C street, through a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Reservation, Massachusetts avenue and Nineteenth street, northwest.—The supply of Potomac water is taken from the 6-inch main on the south side of the circle, through a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Reservation, Massachusetts avenue and Sixteenth street, northwest.—The supply of Potomac water is taken from the 6-inch main in Scott Place, through a pipe 2 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 2,160 gallons.

Circle at Massachusetts avenue and Fourteenth street.—The supply of Potomac water is received from the 6-inch main around the circle by a pipe 2 inches in diameter, with branches 2 inches in diameter. The quantity used daily is estimated at 2,160 gallons.

Reservation, Massachusetts avenue and Tenth street.—The supply of Potomac water is received from 6-inch main in Tenth street, through a pipe 1¼ inches in diameter, with a branch 1¼ inches. The quantity of water used daily is estimated at 540 gallons.

Reservation, Massachusetts avenue and Twelfth street.—The supply of Potomac water is received from the 6-inch main in Twelfth street, through a pipe 1¼ inches in diameter with a branch 1¼ inches in diameter. The quantity of water used daily is estimated at 540 gallons.

Reservation, Massachusetts avenue and Seventh street.—The supply of Potomac water is received from the United States 30-inch main in K street, through a 3-inch pipe, with 2-inch branches. The quantity used daily is estimated at 1,080 gallons.

Reservation, Massachusetts avenue and Fifth street.—The supply of Potomac water is received from the 6-inch main in I street by a pipe 1¼ inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Circle at Rhode Island avenue and Thirteenth street.—The supply of Potomac water is received from the 6-inch main around the circle by a pipe 3 inches in diameter, with branches 2 inches in diameter. The quantity used daily is estimated at 2,160 gallons.

Reservation, Rhode Island avenue and Twelfth street.—The supply of Potomac water is received from the 6-inch main in Twelfth street, through a pipe 1¼ inches in diameter, with a branch 1¼ inches in diameter. The quantity of water used daily is estimated at 360 gallons.

Rawlins Park.—The supply of Potomac water is received from a 4-inch main running diagonally across the park, through a 3-inch pipe, with 2-inch branches. The quantity of water used daily is estimated at 540 gallons.

Reservation, New York avenue and Twelfth street.—The supply of Potomac water is received from a 6-inch main in I street, through a 1¼-inch pipe, with a 1¼-inch branch. The quantity used daily is estimated at 1,080 gallons.

Reservation, New York avenue and Tenth street.—The supply of Potomac water is received from a 6-inch main in Tenth street, through a pipe 1¼ inches in diameter, with a 1¼-inch branch. The quantity of water used daily is estimated at 1,080 gallons.

McPherson Park.—The supply of Potomac water is received from the 6-inch main in Fifteenth street, through a pipe 1¼ inches in diameter, with branches 1¼ inches in diameter. The quantity of water used daily is estimated at 540 gallons.

Farragut Park.—The supply of Potomac water is received from a 6-inch main in Seventeenth street, through a 1¼-inch pipe, with 1¼-inch branches. The quantity of water used daily is estimated at 540 gallons.

Lincoln Park.—The supply of Potomac water is received from the 4-inch main in East Capitol street, through a pipe 4 inches in diameter, with branches 2 inches in diameter. The quantity of water used daily is estimated at 1,080 gallons.

Executive Grounds and greenhouses.—The supply of Potomac water is received from the 12-inch main in Pennsylvania avenue, by a pipe 6 inches in diameter, and from the 4-inch main in Fifteenth street by a pipe 4 inches in diameter. The quantity of water used daily is estimated at 4,800 gallons.

The Capitol Grounds and greenhouses.—The supply of Potomac water is received from the United States 20-inch main in North B street. The quantity of water used daily is estimated at 5,000 gallons.

PUBLIC FOUNTAINS.

The quantity of Potomac water used daily, when flowing 24 hours, is as follows:

	Gallons.
Lincoln Park, 2 fountains	22,356
Massachusetts avenue and First street, northeast, 1 fountain	20,340
New Jersey avenue and M street, 1 fountain	31,200
Judiciary Park, 1 fountain	86,940
Armory Park, 1 fountain	34,776
New York avenue, Tenth and Eleventh streets, 1 fountain	5,197
Iowa Circle, 1 fountain	28,196
Franklin Square, 1 fountain	39,732
Mount Vernon Place, 1 fountain	151,680
Rawlins Park, 2 fountains	27,225
Pennsylvania avenue and Ninth street, 1 fountain	32,445
Treasury, 2 fountains	122,400
Executive Mansion, 2 fountains	487,249
Pennsylvania avenue and Twenty-first street, 1 fountain	38,100
Pennsylvania avenue and Eighteenth street, 1 fountain	9,630
Aqueduct street, Georgetown, 1 fountain	102,240
Total	1,239,646

There are also 52 drinking fountains, which flow on an average 1¾ gallons in 1 minute, which for 24 hours is 131,040 gallons.

ABSTRACT, PUBLIC BUILDINGS.

	Gallons.
Columbia Institute for Deaf and Dumb	18,300
Jail of the District of Columbia	18,400
United States Navy-yard	63,200
Marine Barracks	16,250
Washington Arsenal	28,000
The Capitol	41,400
The City Hall	8,300
United States Coast Survey	6,675
Public Printing Department	74,840
Post-Office Department	29,200
Post-Office Department, 915 E street	3,500
Interior Department	55,300
Interior Department, Pennsylvania avenue and Thirteenth street	4,000
Interior Department, Eighth and G streets	4,000
Pension Bureau	15,400
Army Medical Museum	8,850
Department of Agriculture	22,700
Smithsonian Institution	7,000
Quartermaster-General's Office	17,300
Bureau of Statistics	2,300
Treasury Department	302,959
Treasury Department, Macerator and Machine Shop	8,850
Treasury Department, Photographer's Building	4,020
Executive Mansion	6,650
State Department	28,500
War Department	18,700
Navy Department	16,000
War Department, Old Navy Building	9,200
War Department, Wooden Building	1,300
War Department, Winder's Building	10,800
Buildings occupied by Adjutant-General	6,800
Signal Bureau	2,900
National Observatory	6,300

	Gallons.
United States Civil Engineer Office, 1909 Pennsylvania avenue	600
Columbia Hospital	12,600
Washington Aqueduct Office, Georgetown	1,100
Custom-House	1,900
Total	884,094

PUBLIC PARKS.

Green-houses and nursery	2,800
Monument Grounds	1,800
Smithsonian Grounds	2,160
Armory Park	1,080
Reservation, Maine avenue, Four-and-a-half and Sixth streets	540
Reservation, Missouri avenue, Third and Four-and-a-half streets	1,080
Judiciary Park	4,320
Franklin Park	5,040
La Fayette Park	3,600
Circle, Pennsylvania avenue and Twenty-fourth street	360
Reservation, Pennsylvania avenue and Twenty-first street	360
Reservation, Pennsylvania avenue and Nineteenth street	540
Reservation, Pennsylvania avenue and Eighteenth street	540
Reservation, Pennsylvania avenue and Ninth street	360
Reservation, Massachusetts avenue and Nineteenth street	360
Reservation, Massachusetts avenue and Sixteenth street	2,160
Reservation, Massachusetts avenue and Fourteenth street (circle)	2,160
Reservation, Massachusetts avenue and Tenth street	540
Reservation, Massachusetts avenue and Twelfth street	540
Reservation, Massachusetts avenue and Seventh street	1,080
Reservation, Massachusetts avenue and Fifth street	360
Reservation, Rhode Island avenue and Thirteenth street (circle)	2,160
Reservation, Rhode Island avenue and Twelfth street (circle)	360
Rawlins Park	540
Reservation, New York avenue and Twelfth street	1,080
Reservation, New York avenue and Tenth street	1,080
McPherson Park	540
Farragut Park	540
Lincoln Park	1,080
Executive Grounds and greenhouses	4,800
The Capitol Grounds and greenhouses	5,000
Total	48,960

SUMMARY.

Monument lakes and United States fish and fisheries	322,448
Public buildings	884,094
Public parks	48,960
Public fountains	1,239,646
Public drinking fountains	131,040
Total	2,626,188

B.

SENATE COMMITTEE ON THE DISTRICT OF COLUMBIA TO LIEUTENANT-COLONEL THOS. LINCOLN CASEY, CORPS OF ENGINEERS.

COMMITTEE ON THE DISTRICT OF COLUMBIA,
UNITED STATES SENATE,
Washington, D. C., July 30, 1879.

SIR: I am directed by Senator Isham G. Harris, chairman Committee on District of Columbia, to transmit to you a copy of a resolution adopted by the Senate June 6, 1879, which please find inclosed herewith, and to respectfully request you will cause to be furnished to the committee such information upon the points to which inquiry is directed by the terms of the resolution as is to be obtained from the records of your office.

Your entire familiarity with the subject will doubtless enable you to offer to the committee suggestions of the utmost value, as well as accurate information as to what additional expenditures of money will be required to furnish (1) an ample supply of water, and (2) to render the same as pure as possible. And the committee will be greatly obliged to you for such suggestions and information.

As the subcommittee to whom the subject has been referred will convene on or before the 1st of September next to consider the same and prepare a report thereupon, it is earnestly hoped you will find it convenient to favor the committee through its chairman with an early reply.

Very respectfully,

CHARLES STONE,
Clerk Committee District of Columbia,
United States Senate.

Col. THOMAS L. CASEY,
Commissioner Public Buildings, &c.

RESOLUTION.

Resolved, That the Committee on the District of Columbia be, and hereby is, authorized to sit during the next recess of the Senate, to investigate the best means of securing to the cities of Washington and Georgetown an ample supply of pure water; and to ascertain what the water-works now in use, including the aqueduct, reservoirs, water-mains, &c., have cost the United States, the District of Columbia, and the cities of Washington and Georgetown, and also the annual income that has been secured therefrom, and how much thereof has been realized; and also the present state of all outstanding debts or liabilities relating to said works; and what additional expenditure will be necessary, if any, to secure an ample supply of pure water; and that the committee report to the Senate, by bill or otherwise, at the next session of Congress.

Adopted June 6, 1879.

LIEUTENANT-COLONEL THOS. LINCOLN CASEY, CORPS OF ENGINEERS, TO CHAIRMAN OF THE SENATE COMMITTEE ON THE DISTRICT OF COLUMBIA.

OFFICE OF WASHINGTON AQUEDUCT,
Georgetown, D. C., August 28, 1879.

SIR: I have the honor to acknowledge the receipt of a copy of a resolution adopted by the United States Senate June 6, 1879, which authorizes the Committee on the District of Columbia to sit during the next recess of the Senate to investigate the best means of securing to the cities of Washington and Georgetown an ample supply of pure water; and to ascertain what the water-works now in use, including the aqueduct, reservoirs, water-mains, &c., have cost the United States, the District of Columbia, and the cities of Georgetown and Washington; also, the annual income that has been secured therefrom, and how much thereof has been realized; also, the present state of all outstanding debts or liabilities relating to said works; and what additonal expenditures will be necessary, if any, to secure an ample supply of pure water; together with the receipt of your request that I will cause to be furnished to the Committee such information upon the points to which inquiry is directed by the terms of the resolution as is to be obtained from the records of this office.

In reply the following statement is submitted, commencing with a brief description of the Washington Aqueduct.

The conduit of the Washington Aqueduct is circular in section, and 9 feet in diameter. It is supplied with water from the Potomac River above Great Falls, by means of a stone dam extending across the Maryland channel to Conn's Island. At the head of the conduit there is a gate-house containing a double set of iron gates, by means of which the flow of water from the river is controlled and regulated.

There are two reservoirs, the receiving reservoir and the distributing reservoir. The receiving reservoir is located 47,922 feet below Great Falls, and is a basin formed by building a dam of earth across the valley of Powder Mill Branch.

The distributing reservoir is located at the lower end of the conduit, 10,410 feet west of Washington. There are four gate-houses in connection with it, namely, the influent, the central, the effluent, and the auxiliary.

The total length of the conduit from Great Falls to the distributing reservoir is 60,922 feet. The highest point of the intrados of the conduit in the gate-house at Great Falls is 151 feet above the datum line of the aqueduct (which is mean low-tide at Washington).

In the influent gate-house at the distributing reservoir, a corresponding point is 141.87 feet above datum, making the total fall of the conduit 9.13 feet; but as the flow line of the distributing reservoir is generally kept at from +144 to +145 above datum, the effective fall is consequently reduced to about 6 feet.

The maximum discharge of the conduit when running full, with the surface of water in the distributing reservoir drawn down to the level of +141.87, is 67,259,800 gallons in 24 hours; its minimum discharge when running full, and with the surface of water in the distributing reservoir raised to +144.75, is 54,832,464 gallons in 24 hours.

The top of the dam at Great Falls is 148 feet above datum; and when the water in the river falls to this level, the depth of water in the head of the conduit is but 6 feet. It can then discharge into the distributing reservoir, at +145, 27,113,616 gallons, at +144, 31,608,144 gallons, in 24 hours.

The discharge of the conduit might be increased to 80,000,000 gallons in 24 hours by completing the Potomac dam to the level of +154, or 6 feet above its present height, and lowering the surface of water in the distributing reservoir to +141.87. The total fall would then be 12 feet, and the conduit would be run under a head, which would, it is feared, render the strengthening of its embankments and a modification of its waste-weirs and bridges a necessity.

In practice, the actual discharge into the distributing reservoir is equal to the quantity drawn from the reservoir by the iron mains leading to Washington, except during the season of drought, when the discharge is often less than the consumption, and the water surface of the reservoir lowers.

The object proposed in the construction of the receiving reservoir was twofold. First, to give storage capacity in case of accidents occurring to the conduit; secondly, to furnish a large area in which the water might have opportunity to remain quiet and deposit its impurities. The first object was to some extent accomplished, the capacity being above the bottom of the acqueduct, 176,000,000 gallons.

Experience has shown that the hopes entertained of the purification of the water were not well grounded, and for the following reasons:

Powder Mill Branch and four or five small streams are constantly discharging into the reservoir, and as each of these streams drain a hilly country they are consequently swollen and muddied by every rain. The hillsides sloping up from all sides of the reservoir discharge their surface water into it; while the water for the most part is shallow, the area, compared with the length of shore line, small, and the banks unprotected from the wash of the waves.

This reservoir has an area of 51 acres, with a shore line of about 15,000 feet and a width varying from 200 to 500 feet.

As the expectation that the water from the aqueduct, entering the reservoir some 3,000 feet from the outlet, would diffuse itself over this area and deposit its sediment in the passage, was defeated by Powder Mill Branch, other streams, and the immense unprotected shore line, the conduit above the reservoir was some years ago connected with the conduit below the reservoir, so that the Potomac water might at times be brought directly into the distributing reservoir without adulteration with the water collected from other sources in the receiving reservoir.

The distributing reservoir is, in form, nearly a rectangle, 2,250 feet long and about 850 feet wide at the flow line. The area of its water surface at the flow line (145 feet above datum) is 1,873,080 square feet; its bottom is 135 feet above datum, giving a depth of 10 feet. With this depth of water it contains 136,366,384 gallons. It is divided into two parts by an embankment running across it, the upper division having an area of 1,087,341 square feet, and the lower, 785,739 square feet. The inner faces of its embankments are lined with slope wall 12 to 18 inches thick, laid on a bed of broken stones 6 inches thick. On the north side of the reservoir a conduit 7 feet in diameter connects the 9-foot conduit with the effluent gate-house, by which means the Potomac water can be carried past the reservoir, directly to the cast-iron mains at its lower end. The dividing bank has a gate-house so arranged and connected with the effluent gate-house that the water can be drawn at pleasure from either section, and the lower section can also be supplied with water from the upper section.

The object of the distributing reservoir, as constructed, was this: The water was to be introduced at the upper end, either from the Potomac River or the receiving reservoir, whichever, for the time being, was the clearest; and then, having time and space to settle, was to flow over the overfall in the division embankment, and be drawn to the city from the other end of the lower division. Also, if at any time the water, either in the Potomac or receiving reservoir, or both, was too muddy for immediate use, the water from above was then to be shut off temporarily from the distributing reservoir, and the supply was to be drawn from the upper division until it became exhausted, after which the draft would commence from the lower section, while the upper one would be replenished either from the Potomac River or the receiving reservoir, from either of which the water could also at any time be supplied directly to the iron mains.

The benefits expected from this arrangement have not been realized, owing to the small area given to the reservoir.

As previously stated, its capacity above the level of + 135 is 136,366,384 gallons, which, at the present rate of consumption (26,000,000 gallons daily), is equal to about

5 days' supply. It will, therefore, readily be seen that when the Potomac is turbid at the head of the aqueduct, it must, unless shut off, soon displace the clear water in the reservoir; and, if it should be shut off for 5 days, the reservoir would be practically emptied. In fact the surface of the upper division would be lowered over 3 feet daily, the ill effects of which would be immediately felt in the reduced pressure in the mains and pipes in the city.

MAINS LAID BY THE UNITED STATES.

In the effluent gate-house at the distributing reservoir are four 48-inch mouthpieces, for the attachment of mains for the supply of the city; one of these mouthpieces is capped in the pipe-vault, another is reduced to 30 inches in the vault, a third to 12 inches, and the fourth to 36 inches; and from each of the reduced pieces a main is laid off to the city.

Leaving the vault the 12 and 30 inch mains run parallel across the country to Foundry Branch. From there they follow the road along the canal to College Pond, which is crossed by an arch of 120 feet span.

From this point they are continued along the canal road and Bridge and Aqueduct streets, in Georgetown, to Rock Creek. Here the mains are enlarged to 48 inches in diameter, and form an arch of 200 feet span across the creek. In the west abutment of this bridge a branch from the 30-inch main is laid through Aqueduct, Green, West, and High streets, to the high-service reservoir, Georgetown.

This branch is 12 inches in diameter for 1,550 feet, and is then reduced to 10 inches for 3,538 feet. At the east end of Rock Creek Bridge the pipes are reduced respectively to 12 and 30 inches. The 30-inch main follows Pennsylvania avenue to the Circle, then deflects to the left, and passes through K Street, Massachusetts avenue and New Jersey avenue to B street north, where it is reduced to 20 inches in diameter, and passes up B street to First street east, where it connects with the District of Columbia 20-inch main.

The 12-inch main starting from Rock Creek follows the line of Pennsylvania avenue and Eighth street east, to the navy-yard wharf.

From the corner of B street north and New Jersey avenue, a 20-inch main runs through the reservation, Maine avenue, and B street south, to a point opposite the south door of the Smithsonian Institution.

The branches from the 20-inch main are:

1. A 12-inch pipe down Four-and-a-half street to the United States Arsenal.
2. A 12-inch pipe in the Smithsonian grounds.
3. A 6-inch pipe to the south door of the Smithsonian building.

From the 30-inch main branches a 12-inch pipe at Twenty-fourth street west, which runs down that street to the Observatory gate.

The branches from the 12-inch main are—

1. At Eighth street west a 12-inch pipe runs up Eighth street, down F street, and up Seventh street, supplying the Post-Office and Interior Department buildings.
2. A 12-inch pipe up Four-and-a-half street to Judiciary Square.

Besides the above mains laid by the United States, the following were laid by the District of Columbia, under the direction of the Engineer officer in charge of the Washington Aqueduct:

1. A 36-inch main which, leaving the pipe-vault at the distributing-reservoir, runs parallel with the 12 and 30 inch mains to Rock Creek, where it is enlarged to 48 inches and connected with the north arch of the bridge. At the east end of the bridge it is reduced to 36 inches, and follows Pennsylvania avenue to L street, and L street to New Jersey avenue.
2. At L street and New Jersey avenue a 30-inch branch which connects with the 36-inch main and runs down New Jersey avenue to Massachusetts avenue, where it connects with the United States 30-inch main.
3. At First street east and B street north a 20-inch main, which connects with the United States 20-inch main, and runs out B street to Eleventh street east.

MEANS OF SECURING TO THE CITIES OF WASHINGTON AND GEORGETOWN AN AMPLE SUPPLY OF WATER.

The consumption of Potomac water is yearly increasing, and has reached nearly the maximum quantity that can be supplied by the 12-inch, 30-inch, and 36-inch mains. For a series of years the average daily consumption has been nearly as follows:

	Gallons.
1874	17,554,848
1875	21,000,000
1876	24,177,797
1877	23,252,932
1878	24,885,945
1879	25,947,642

To increase the supply it is suggested that another main be laid from the distributing reservoir to Capitol Hill. It should be 3 feet in diameter, and located on a route to be determined from a careful survey. It would convey to Capitol Hill, at an elevation of 115 feet above datum, 12,000,000 gallons in 24 hours.

The furnishing of this additional quantity of water to the city would render the completion of the Potomac dam a necessity.

This method of relieving the pressing necessities of certain parts of the city is suggested as the most expeditious and least costly method for the immediate relief of Capitol Hill; but looking to the future when the whole capacity of the conduit may be required to supply Georgetown and Washington, the extension of the conduit from the distributing reservoir to the high grounds north of Washington, and there building a distributing reservoir and connecting it by well-arranged lines of mains with the city distribution pipes, would doubtless be the best solution of the problem.

No detailed survey of the route to be followed by this new conduit or of the site of the reservoir has been made in this office, a necessary preliminary to any careful estimate of cost.

The quantity of water that would be brought to the new reservoir by running the conduit full, and not under a head, would be 67,000,000 gallons daily, delivered in the new reservoir at an elevation of about 139 feet above datum.

Another method of securing an ample supply of water would be to take up the mains now conveying the water into the two cities, and to lay mains of larger diameter.

METHOD BY WHICH POTOMAC WATER CAN BE DELIVERED IN GEORGETOWN AND WASHINGTON CLEAR AND PURE.

River water contains almost constantly inorganic matter, which matter is enormously increased at periods of floods. The heavier particles of this inorganic matter are speedily deposited, but the light particles which give to the water a cloudy appearance are retained in suspension a much longer period, and can only be removed by the process of filtration.

Observations of the comparative clearness of the Aqueduct water at Great Falls, the receiving reservoir, and the distributing reservoir, have been taken and recorded daily for the past two years. The following table is for the year ending June 30, 1879:

Name of source.	Number of days that the water was—			
	Clear.	Slightly turbid.	Turbid.	Very turbid.
Great Falls	167	67	71	120
Receiving reservoir	152	72	67	74
Distributing reservoir	195	38	94	38

The condition of the water delivered in Georgetown and Washington is similar to that in the distributing reservoir. For the present, the Potomac water can be brought to a respectable degree of clearness by enlarging the area of the distributing reservoir to such an extent as will afford the water ample time to settle and deposit its sediment.

It will be seen from the above table that the water has been as clear as river water naturally can be, for 195 days during the year. If the area of the distributing reservoir were enlarged to 200 acres, or, in case there is not sufficient land adjoining it of a suitable formation, if another reservoir were built or a series of reservoirs, divided into compartments by overfall embankments, it is believed that the Potomac water could be delivered in Georgetown and Washington comparatively clear and free from earthy sediment. To render it perfectly clear—as clear as crystal—the water of the Potomac, like that of other rivers, must be filtered.

FILTRATION.

The filtration of water on the large scale has been practiced in England and on the continent of Europe for many years. In the United States the practice of the filtration of water, on water-works, is but just beginning to come into use.

In the year 1866, James P. Kirkwood, civil engineer, went to Europe in the interests of the city of Saint Louis, to study the clarification of river waters used for the supply of cities; and his elaborate report on the subject of filtration in general is comprehensive and contains full details of European practice, as well as plans and suggestions for filtering beds for Saint Louis.

Saint Louis has not yet adopted any system of filtration, but several other cities of smaller size have done so with more or less success, namely, Poughkeepsie, N. Y., in 1871, Hudson, N. Y., in 1874, and Toledo, Ohio, in 1875. The necessity of filtration is, however, in many places felt, and would, no doubt, have been long since undertaken were it not for the additional outlay required for subsiding basins and filter beds, and the expense of maintenance.

Filter beds as usually constructed, are water-tight basins some 10 feet or more in depth, the sides built of masonry, and the bottom puddled or made of concrete or paved with brick and cemented. The area may be from 20,000 to 50,000 square feet, or, in some cases, even 150,000 square feet. In building up the filtering beds, provision is first made for the ready collection of the water by constructing upon the floor of the basin drains or channel-ways of stone or brick, laid dry. Then follows a layer of broken stone, the fragments being 3 or 4 inches in diameter. This is succeeded by gravel screened so as to be of uniform size; a layer of coarser being followed by one or more layers of fine material; upon the gravel rests sand likewise separated into layers of uniform size. The exact thickness of the different layers, and the extent to which the separation of the different sizes is carried, are subject, of course, to considerable variation.

The water stands several feet deep over the surface of the sand, and is allowed to flow down through the filter at such rate as experience shows to be most advantageous. Naturally, when the sand is clean, a greater quantity of water will pass in a given time than when the sand has become clogged. Practice differs as to the maximum rate, but it is seldom over 6 inches vertically per hour, and often less. At this rate each square foot of surface would deliver 89¾ gallons per day. When the beds become clogged so as no longer to filter with sufficient rapidity, the water is drawn down to from 12 to 14 inches below the upper surface of the filtering beds, and the upper layer of sand for a depth of one-half or three-quarters of an inch is removed.

When, by successive parings, the thickness of the sand has been considerably reduced, that which has been removed is washed and replaced so as to restore the original thickness; the waste of washing being made up with fresh sand. Up to the present time no filtering material has proved practically available, on the large scale, except sand, although various attempts have been made to use other substances.

Poughkeepsie, N. Y., was the first city in this country to adopt a scheme for the artificial filtration of the entire water supply, and the filter beds are built upon the English model. The filtering works consist of a settling-basin 25 by 60 feet in plan and 12 feet deep. The two filter beds are each 200 by 73½ feet in plan, and 12 feet deep, built with vertical walls; each has therefore 14,700 square feet of filtering area. The 6 feet of filtering material, beginning at the top of the bed, are disposed as follows:

24 inches sand.
6 inches ¼-inch gravel.
6 inches ½-inch gravel.
6 inches 1-inch gravel.
6 inches 2-inch broken stone.
24 inches 4 to 8 inch broken stone.
—
Total, 72 inches.

The beds have a concrete bottom 12 inches in thickness, upon which are arranged open stone culverts to conduct the filtered water to the intermediate basin. The flow of the water from each bed to the intermediate basin is controlled by a gate, so that while one bed is being cleaned the other may be used. The original cost of the beds was about $54,000. The entire amount of water filtered during the year 1876 was 540,927,452 gallons, and the cost of maintenance about $3.50 per million gallons.

Assuming the size of a filter bed for the Washington Aqueduct to be one acre, this area would filter 3,909,510 gallons in 24 hours. To filter 26,000,000 gallons daily, eight filters of this size would be necessary, on the supposition that the flow of water through seven of them is continuous through the 24 hours.

The successful use of the filter bed presupposes the preparation of the water in a subsiding reservoir; for, whenever the attempt has been made to use filter beds without that preliminary aid, they have either failed altogether or rendered the water but partially clarified.

The cost of constructing filter beds of sufficient capacity to filter 26,000,000 gallons daily is estimated at $470,000, and the cost of a settling basin of an area of 160 acres is estimated at $443,400; total, $913,400.

The cost of maintenance and attendance is estimated at $3 per million gallons, which is $78 per day, or $28,470 per year.

Seeing that the cost of works for filtration is so great, and that a large quantity of Potomac water used in the cities of Washington and Georgetown does not need to be filtered, it is submitted whether it is not better to leave the filtration of the water, as it is now left, to the individual taste of the consumer.

COST OF THE WASHINGTON AQUEDUCT.

The following table shows the amounts appropriated by Congress on account of the Washington Aqueduct, from September, 1850, to June, 1878, including engineering, right of way, construction, maintenance, and repairs.

STATEMENT OF APPROPRIATIONS FOR THE WASHINGTON AQUEDUCT FROM SEPTEMBER 30, 1850, TO JUNE 30, 1878.

Act of September 30, 1850	$500 00
Act of August 31, 1852	5,000 00
Act of March 3, 1853	100,000 00
Act of March 3, 1855	250,000 00
Act of August 18, 1856	250,000 00
Act of March 3, 1857	1,000,000 00
Act of June 12, 1858	800,000 00
Act of June 25, 1860	500,000 00
Act of July 4, 1864	150,000 00
Act of July 28, 1866	51,687 00
Act of July 28, 1866	70,897 00
Act of July 28, 1866	4,000 00
Act of July 28, 1866	1,060 00
Act of July 28, 1866	15,000 00
Act of December 20, 1866	12,000 00
Act of March 2, 1867	20,000 00
Act of July 25, 1868	27,500 00
Act of July 25, 1868	25,000 00
Act of March 3, 1869	25,000 00
Act of July 15, 1870	1,320 00
Act of July 15, 1870	1,012 00
Act of July 15, 1870	550 00
Act of July 15, 1870	3,300 00
Act of July 15, 1870	2,640 00
Act of July 15, 1870	5,500 00
Act of July 15, 1870	1,500 00
Act of July 15, 1870	20,000 00
Act of July 15, 1870	55,000 00
Act of July 15, 1870	4,000 00
Act of July 15, 1870	4,000 00
Act of July 15, 1870	12,000 00
Act of July 15, 1870	10,000 0
Act of March 3, 1871	10,000 00
Act of March 3, 1871	10,000 00
Act of March 3, 1871	20,496 00
Act of March 3, 1871	4,000 00
Act of March 3, 1871	2,800 00
Act of March 3, 1871	3,600 00
Act of March 3, 1871	3,300 00
Act of March 3, 1871	20,000 00
Act of March 3, 1871	20,000 00
Act of March 3, 1871	20,000 00
Act of June 10, 1872	1,500 00
Act of June 10, 1872	13,934 00
Act of June 10, 1872	2,500 00
Act of June 10, 1872	15,000 00
Act of June 10, 1872	11,550 00
Act of June 10, 1872	22,932 00
Act of June 10, 1872	3,139 00
Act of January 23, 1873	14,000 00
Act of March 3, 1873	1,500 00
Act of March 3, 1873	2,500 00
Act of March 3, 1873	8,600 00
Act of March 3, 1873	16,000 00
Act of March 3, 1873	15,000 00
Act of June 23, 1874	15,000 00
Act of June 23, 1874	1,500 00
Act of June 23, 1874	3,000 00
Act of June 23, 1874	5,800 00
Act of June 23, 1874	1,100 00
Act of June 23, 1874	5,000 00
Act of June 23, 1874	5,000 00

Act of March 3, 1875	$3,000 00
Act of March 3, 1875	5,000 00
Act of March 3, 1875	15,000 00
Act of March 3, 1875	3,000 00
Act of July 31, 1876	18,000 00
Act of July 31, 1876	4,000 00
Act of March 3, 1877	15,000 00
Act of June, 1878	15,000 00
Total	3,785,157 00

Of the above amount $3,784,546.72 has been expended, and $610.28 has reverted to the Treasury.

The United States has derived no income from the Washington Aqueduct, and there are no outstanding debts nor liabilities that are recognized by this office.

SUMMARY OF EXPENDITURE THAT WILL BE NECESSARY TO SECURE AN AMPLE SUPPLY OF PURE WATER.

First. The estimated cost of laying a main 3 feet in diameter from the distributing reservoir to Stanton Place, on Capitol Hill, is $398,948. This estimate is based on the supposition that the main will be about 28,000 feet long, and that the iron will cost, delivered at Washington, 1¾ cents a pound.

Second. The estimated cost of constructing filter beds to filter 26,000,000 gallons of water daily, including a settling reservoir of 160 acres, is $913,400, and the cost of maintenance and attendance is estimated at $3 per million gallons, or $28,470 a year.

Whichever method is adopted to increase the supply, to its estimated cost must be added the cost of completing the Potomac Dam, which is estimated at $200,000, and to either method should also be added the cost of enlarging the area of the distributing reservoir, or building another reservoir or series of reservoirs, so as to increase the water area to 200 acres, which is estimated at $443,400.

I inclose with this a map of the Washington Aqueduct, a map of the distributing reservoir, a map of the receiving reservoir, and a map of the city of Washington, showing the United States mains in red lines.

All of which is respectfully submitted.

THOMAS LINCOLN CASEY,
Lieutenant-Colonel of Engineers,
In charge of Washington Aqueduct.

Hon. ISHAM G. HARRIS,
Chairman Committee on District of Columbia.

SURVEYS AND EXPLORATIONS.

APPENDIX O O.

SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

REPORT OF MAJOR C. B. COMSTOCK, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A., OFFICER IN CHARGE OF THE WORK, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

UNITED STATES LAKE SURVEY OFFICE,
Detroit, Mich., July 1, 1880.

GENERAL: I have the honor to submit the following report on the survey of the Northern and Northwestern Lakes for the year ending June 30, 1880:

FIELD WORK.

Soon after July 1, 1879, the triangulation east from Chicago needed to connect Lake Michigan with Lake Erie was completed, and the primary triangulation parties of Assistant Engineers G. Y. Wisner, R. S. Woodward, and J. H. Darling were transferred to the triangulation south from Chicago, needed to prolong the arc of meridian through Saint Ignace to a valuable length for geodetic purposes, and to connect with the Coast Survey chain of primary triangulation running east from Saint Louis.

In August another primary triangulation party, under Assistant Engineer A. R. Flint, was added to the others, and the chain of triangles was completed on December 5, 1879, the southern end being at Parkersburg, Ill.

Assistant Engineer Flint determined azimuth at primary station Parkersburg.

In July, 1879, Capt. D. W. Lockwood, Corps of Engineers, at the Lake Survey office in Detroit, in connection with First Lieut. P. M. Price, Corps of Engineers, at Olney, Ill., determined the difference of longitude of these points by four nights of time work and exchange of clock signals. They also determined their relative personal equation by two nights' work before and two nights' work after the longitude work.

Lieutenant Price also determined the latitude of the primary station Parkersburg by four nights' observations with zenith telescope.

In May, 1880, Assistant Engineer G. Y. Wisner observed for latitude at primary stations West Base and Fairmount, Ill., obtaining good determinations on four nights at each place.

At some of the primary triangulation stations occupied in previous years the wooden structures have blown down, and in one case at least

it is known that the surface marks for the triangulation station have been removed. To enable the underground marks to be found, even after the surface marks have been removed, it has been deemed best to have topographical sketches made, in some detail, of the immediate vicinity of most of these stations. Assistant Engineers A. N. Darrow, H. C. Gould, and W. M. Childs have been engaged on this work, and have nearly completed it.

The observations of the water levels of the lakes have been continued at Sacket's Harbor and Charlotte, N. Y., at Erie, Pa., at Cleveland, Ohio, at Detroit, Port Austin, Sault Ste. Marie, Marquette, and at Escanaba, Mich., and at Milwaukee, Wis.

The following table gives a *résumé* of the field work done between July 1, 1879, and June 30, 1880:

Longitudes determined telegraphically	1
Latitudes determined	3
Primary triangulation stations occupied	41
Primary base lines measured	1
Primary azimuths determined	1

OFFICE WORK.

The adjustment of the primary triangulation of the Lake Survey, including last summer's field work, has been completed by Assistant Engineers O. B. Wheeler, W. Voigt, C. H. Kummel, G. Y. Wisner, T. Russell, and J. H. Darling.

The reduction of the Chicago, Sandusky, and Olney bases has been nearly completed by Assistant Engineers E. S. Wheeler, T. W. Wright, L. L. Wheeler, W. Upton, and J. B. Johnson, and only waits for the adoption of final values for the constants of tube 2 of the Repsold base apparatus.

The reduction of vertical angles for trigonometric levels in Michigan and Illinois has been begun.

The reduction of the longitude work at Olney and latitude work at Parkersburg has been completed, and that of azimuth work at Parkersburg and of the latitude work at West Base and Fairmount has been begun.

Comparisons for determining the constants of the Repsold base apparatus tubes have been continued and the work has been partially reduced. Comparisons of standard meter (R. 1876) with Clarke yard A have been continued.

The Lake Survey thermometer, Casella 21472, has, through the kindness of Prof. H. A. Rowland, of the Johns Hopkins University, been compared with the thermometers Baudin 6163 and 6165 of the Johns Hopkins University. As these last have been very carefully compared with an air thermometer by Professor Rowland, we are now enabled to correct Casella 21472 so as to reduce its readings to those of a perfect gas thermometer.

Further comparisons of 21472 with the other principal thermometers of the Lake Survey have been made by Assistant Engineer T. Russell, and the corrections needed to reduce their readings to those of a perfect gas thermometer are given in Appendix No. 5.

Prof. W. Foerster, director of the Normal Eichungs Amt, Berlin, has kindly furnished me with the results of his comparisons of our standard meter (R. 1876). They are given in Appendix No. 1.

Instructions for precise leveling have been prepared under my direction by Assistant Engineer L. L. Wheeler; they are given in Appendix No. 6.

The reduction of water-level observations has been continued.

A list of the manuscript original detail sheets of the Lake Survey has been prepared and is given in Appendix No. 9.

The preparation of the final report of the Lake Survey has been continued, and it may be estimated as half completed.

The following-named charts have been completed; the first two have been photolithographed and the last two are now in the hands of the photolitholograher:

New chart of Lake Erie, scale 1:400000, reduced by Mr. J. U. Mueller.

Coast Chart No. 6, Lake Erie from Vermilion to Port Clinton, Ohio, and from Point Peleé, Ontario, to Detroit River, scale 1:80000, reduced by Mr. Edward Molitor.

Coast Chart No. 5, Lake Erie from vicinity of Fairport to Vermillion, Ohio, scale 1:80000, reduced by Mr. A. de Witzleben.

Coast Chart No. 1, Lake Erie from Buffalo to Dunkirk, N. Y., scale 1:80000, reduced by Mr. Max Franke.

Coast Chart No. 7, Lake Erie, is now in the hands of the draughtsman.

APPENDIXES.

The results of Prof. W. Foerster's comparisons of our standard meter (R. 1876) are given in Appendix No. 1.

The letters of Prof. H. A. Rowland and W. W. Jacques in reference to the comparisons of thermometer Casella 21472 with Baudin thermometers 6163 and 6165 are given in Appendix No. 2.

The results of longitude and latitude work by Captain Lockwood and Lieutenant Price, at Olney and Parkersburg, Ill., are given in Appendix No. 3.

The reports of chiefs of parties are given in Appendix No. 4.

The corrections to reduce the readings of the principal thermometers of the Lake Survey to those of a perfect gas thermometer are given in Appendix No. 5.

Instructions for precise leveling are given in Appendix No. 6.

The results of water-level observations are given in Appendix No. 7.

A list of the published charts of the Lake Survey and the number issued in different years is given in Appendix No. 8.

A list of the original manuscript detail maps of the Lake Survey is given in Appendix No. 9.

Sketches of the general progress of the Lake Survey and of the triangulation south from Chicago are forwarded herewith.

The following officers of Engineers have been on duty on the survey:

Capt. D. W. Lockwood, until February 14, 1880, when he was relieved; First Lieut. P. M. Price, during the year.

FINANCIAL.

Amount available for survey of Northern and Northwestern Lakes on July 1, 1879	$85,000 00
Amount expended in fiscal year ending June 30, 1880	82,360 12
Amount available for Lake Survey on July 1, 1880	40,000 00
Amount required for survey of Northern and Northwestern Lakes for fiscal year ending June 30, 1882	18,000 00

Estimate of funds for continuance of Surveys of Northern and Northwestern Lakes for the fiscal year ending June 30, 1882.

For water-level observations and reductions, comparisons of standards of base apparatus and reductions, printing and issuing charts for use of navigators, completion of publication of final report, office rent, clerk hire, fuel, and miscellaneous	$18,000

Details as follows:

Water-level observations and reductions	$2,500
Comparisons of standard of base apparatus and reduction	2,500
Printing and issuing charts for use of navigators	3,000
Completion of publication of final report	5,000
Office rent, clerk hire, fuel, and miscellaneous	5,000
Total	18,000

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Major of Engineers,
Bvt. Brig. Gen., U. S. A.

The CHIEF OF ENGINEERS, U. S. A

APPENDIX No. 1.

RESULTS OF COMPARISONS OF LAKE SURVEY STANDARD METER (R, 1876), BY PROFESSOR W. FOERSTER, BERLIN.

BERLIN, *den* 16 *April*, 1879.

In Beantwortung des gefälligen Schreibens vom 17. v. M. erlaube ich mir, Ihnen zunächst ein Verzeichniss der blossen Eintheilungsfehler Ihres stählernen Meterstabes von Repsold und des zugehörigen Decimeters zu übersenden, indem ich bezüglich der noch restirenden, von Ihnen dringend gewünschten anderweitigen Festsetzungen folgendes ergebenst bemerke:

Der hauptsächliche Grund der Verzögerung besteht darin, das wir durch dringliche laufende Aufgaben bisher noch immer verhindert worden sind, absolute Ausdehnungsbestimmungen zu machen. Indessen sind wir wenigstens im letzten Winter dazu gelangt, gute relative Ausdehnungsbestimmungen eines Stahlmeters und eines Messingmeters gegen einen Platinstab zu machen, dessen absolute Ausdehnung ziemlich nahe bekannt ist. Die Ergebnisse dieser Bestimmungen werden in zwei bis drei Wochen so weit abgeschlossen sein können, dass ich hoffe in 4 bis 5 Wochen Ihnen die Längen Ihrer Massstäbe gegen den erwähnten Platinstab und die zugehörigen Ausdehnungswerthe zu übersenden. Einige ungefähre Bestimmungen werden vielleicht schon früher Ihnen zugehen können.

Wir werden zur Beschleunigung der Sache von Ihrer Ermächtigung einer Kostenliquidation die wir bisher in allegemein wissenschaftlichen Interesse zu unterlassen beabsichtigt hatten, nunmehr vollen Gebrauch machen.

Kaiserliche Normal Eichungs-Kommission.

FOERSTER.

To the OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich.

Beglaubigtes Fehlerverzeichniss

der sämmtlichen Striche eines biegungsfreien Strichmaasses von Stahl mit Theilung von 1 Meter Länge auf Platin und einer zugehörigen gleichfalls auf Platin getheilten Decimeterskala von Stahl, verfertigt von A. Repsold Söhne in Hamburg, zur Prüfung eingereicht von dem Office of U. S. Lake Survey, in Detroit, Michigan.

I.—Das Strichmass von 1 Meter Länge.

[*a*, die Zehntelmillimeterstriche; *b*, die Millimeterstriche; *c*, die Centimeterstriche; *d*, die Decimeterstriche.]

Theilstrich.	Fehler.	Theilstrich.	Fehler.	Theilstrich.	Fehler.	Theilstrich.	Fehler.	Theilstrich.	Fehler.
− 0.1	0	0	0	50	+ 1	0	0	0	0
0.0	0	1	− 1	51	+ 1	1	+ 2.6	1	− 0.5
+ 0.1	− 1	2	− 1	52	+ 2	2	+ 2.4	2	− 2.5
0.2	+ 1	3	0	53	+ 1	3	+ 2.9	3	− 1.5
0.3	+ 1	4	0	54	− 1	4	+ 2.4	4	− 1.1
0.4	+ 2	5	+ 1	55	+ 1	5	+ 1.1	5	− 1.6
0.5	− 1	6	0	56	0	6	+ 0.6	6	+ 0.5
0.6	+ 1	7	0	57	0	7	+ 1.2	7	− 1.4
0.7	0	8	+ 1	58	0	8	− 0.6	8	− 0.1
0.8	0	9	+ 1	59	+ 1	9	+ 1.0	9	− 0.5
0.9	− 2	10	+ 3	60	+ 1	10	− 0.6*	10	0
1.0	− 1	11	+ 2	61	+ 2				
1.1	+ 1	12	+ 2	62	+ 1				
		13	+ 2	63	+ 1				
		14	+ 2	64	+ 1				
		15	+ 3	65	+ 3				
		16	+ 2	66	+ 2				
		17	+ 3	67	+ 2				
		18	+ 3	68	+ 2				
		19	+ 3	69	+ 2				
		20	+ 2	70	+ 1				
		21	+ 2	71	+ 2				
		22	+ 2	72	+ 1				
		23	+ 3	73	+ 1				
		24	+ 1	74	0				
		25	+ 2	75	0				
		26	+ 3	76	0				
		27	+ 2	77	0				
		28	+ 2	78	0				
		29	+ 3	79	0				
		30	+ 3	80	− 1				
		31	+ 4	81	0				
		32	+ 3	82	0				
		33	+ 3	83	+ 1				
		34	+ 2	84	+ 1				
		35	+ 3	85	+ 1				
		36	+ 2	86	+ 1				
		37	+ 3	87	+ 1				
		38	+ 2	88	+ 3				
		39	+ 1	89	− 1				
		40	+ 2	90	+ 1				
		41	+ 1	91	0				
		42	+ 2	92	− 1				
		43	+ 1	93	+ 1				
		44	+ 1	94	0				
		45	+ 1	95	+ 1				
		46	+ 1	96	+ 1				
		47	+ 1	97	0				
		48	+ 1	98	+ 1				
		49	0	99	0				
		50	+ 1	100	+ 1*				

VERBÜRGBAR.

bei *a* und *b*........ 1.0 bis 1.5^{μ}
bei *c* und *d*........ 0.2 bis 0.3^{μ}

Die Gesammtlänge ist noch nicht bestimmt worden.

* See Foerster's letter of June 20, 1879.

II.—Die Decimeterskala.

[*a*, die Zehntelmillimeterstriche; *b*, die Millimeterstriche.]

a

Theilstrich.	Fehler.
− 0.1	+ 0.6
0.0	0.
0.1	+ 0.3
0.2	+ 0.9
0.3	+ 0.4
0.4	+ 0.9
0.5	− 0.1
0.6	+ 0.4
0.7	+ 0.2
0.8	− 0.1
0.9	+ 0.1
1.0	− 0.2
1.1	+ 1.6

Verbürgbar 0.3 bis 0.5^{μ}.

b

Theilstrich.	Fehler.	Theilstrich.	Fehler.
0	0.0	50	+ 1.0
1	0.0	51	+ 1.0
2	− 0.5	52	+ 1.0
3	0.0	53	+ 1.0
4	0.0	54	+ 1.5
5	0.0	55	+ 1.0
6	+ 1.5	56	+ 1.0
7	+ 1.0	57	+ 0.5
8	+ 1.0	58	+ 1.5
9	0.0	59	+ 0.5
10	+ 1.0	60	+ 0.1
11	0.0	61	+ 1.5
12	+ 1.0	62	+ 1.0
13	+ 0.5	63	0.0
14	− 0.5	64	+ 1.0
15	− 0.5	65	+ 1.5
16	− 1.5	66	+ 1.0
17	− 1.0	67	+ 1.5
18	− 0.5	68	0.0
19	− 0.5	69	+ 1.0
20	− 0.5	70	+ 1.5
21	− 0.5	71	+ 0.5
22	− 0.5	72	0.0
23	− 0.5	73	+ 0.5
24	− 0.5	74	− 0.5
25	0.0	75	0.0
26	+ 0.5	76	0.0
27	0.0	77	0.0
28	− 0.5	78	0.0
29	− 1.0	79	0.0
30	− 0.5	80	+ 1.0
31	0.0	81	0.0
32	0.0	82	0.0
33	0.0	83	− 0.5
34	− 1.5	84	+ 1.0
35	+ 0.5	85	+ 2.0
36	0.0	86	+ 1.0
37	− 0.5	87	+ 2.0
38	− 1.0	88	+ 2.5
39	+ 0.5	89	+ 0.5
40	0.0	90	+ 1.0
41	0.0	91	0.0
42	0.0	92	− 0.5
43	− 1.0	93	0.0
44	0.0	94	− 1.5
45	+ 2.0	95	0.0
46	+ 0.5	96	0.0
47	0.0	97	+ 1.0
48	+ 0.5	98	0.0
49	+ 1.5	99	− 0.5
50	+ 1.0	100	0.0

Verbürgbar 0.5 bis 1^{μ}.

Die Gesammtlänge ist nicht bestimmt worden. In vorstehenden Verzeichnissen bedeutet das (positive, negative), Zeichen, dass das Intervall zwischen dem Nullstrich und den betreffenden Theilstrich um die danebenstehende Anzahl von Tausendtheilen des Millimeter (grosser, kleiner), ist als das in der Bezifferung ausgedrückte nominelle Verhältniss dieses Intervalles zu der Gesammtlänge, d. h. zu demjenigen Abstande, welcher auf dem Meterstabe zwischen dem Null- und 1,000 Millimeterstrich, auf der beigegebenen Decimeterskala zwischen dem Null- und 100 Millimeterstrich enthalten ist.

BEISPIEL.

Für den Centimeterstrich 7 findet man in dem Verzeichniss die Zahlenangabe + 1. 2 d. h. das Intervall zwischen dem Null- und dem 7 Centimeterstrich beträgt 1. 2 Tausend Theile des Millimeter mehr als $\frac{70}{1000}$ des Abstandes des Nullstriches des Maassstabes von dem 1000 Millimeterstrich.

Der wahre metrische Werth jedes Intervalles kann erst gefunden werden, wenn die oben definirte Gesammtlänge und der Ausdehnungs-Coefficient des Stabes, bezw. der Decimeterskala bekannt sein wird.

Berlin, den 16. April 1879.

Kaiserliche Normal Eichungs-Kommission.
Im Auftrage.
BAUMANN I.

[Translation.]

BERLIN, *April* 16, 1879.

In reply to your kind letter of March 17, permit me to send you a list of the errors of graduation of the steel meter made for you by Repsold, and also of the accompanying decimeter scale.

With reference to the further determinations, urgently desired by you, I wish to say that the chief cause of delay in making absolute expansion determinations was pressing current business. Last winter, however, we succeeded in making good relative expansion determinations of a steel meter and of a brass meter with a platinum bar whose absolute expansion is known pretty nearly. The results of these determinations will be so far completed in two or three weeks, that I hope to be able in four or five weeks to send to you the lengths of your measures with reference to the platinum bar above mentioned, and also their respective expansion values.

Some approximate determinations will perhaps be sent sooner.

We will, in order to hasten your business, make full use of the authority given for payment of expenses which we have hitherto been in the habit of neglecting in general scientific interests.

Kaiserliche Normal Eichungs-Kommission.
FOERSTER.

To the OFFICE OF U. S. LAKE SURVEY,
Detroit, Mich.

CERTIFIED LIST OF ERRORS

of each one of the graduations of a line meter measure made of steel, graduated on platinu and free from flexure, also a similarly constructed decimeter scale, both made by Repsol & Sons, Hamburg, submitted for examination by Office of United States Lake Survey, Detroi Mich.

I.—THE LINE MEASURE 1^m IN LENGTH.

[*a* the tenth mm. graduations; *b*, the mm. graduations; *c*, the cm. graduations; *d*, the dm. graduation

Graduations.	Errors.
− 0.1	0
0.0	0
+ 0.1	− 1
0.2	+ 1
0.3	+ 1
0.4	+ 2
0.5	− 1
0.6	+ 1
0.7	0
0.8	0
0.9	− 2
1.0	− 1
1.1	+ 1

Graduations.	Errors.	Graduations.	Errors.
0	0	50	+ 1
1	− 1	51	+ 1
2	− 1	52	+ 2
3	0	53	+ 1
4	0	54	− 1
5	+ 1	55	+ 1
6	0	56	0
7	0	57	0
8	+ 1	58	0
9	+ 1	59	+ 1
10	+ 3	60	+ 1
11	+ 2	61	+ 2
12	+ 2	62	+ 1
13	+ 2	63	+ 1
14	+ 2	64	+ 1
15	+ 3	65	+ 3
16	+ 2	66	+ 2
17	+ 3	67	+ 2
18	+ 3	68	+ 2
19	+ 3	69	+ 2
20	+ 2	70	+ 1
21	+ 2	71	+ 2
22	+ 2	72	+ 1
23	+ 3	73	+ 1
24	+ 1	74	0
25	+ 2	75	0
26	+ 3	76	0
27	+ 2	77	0
28	+ 2	78	0
29	+ 3	79	0
30	+ 3	80	− 1
31	+ 4	81	0
32	+ 3	82	0
33	+ 3	83	+ 1
34	+ 2	84	+ 1
35	+ 3	85	+ 1
36	+ 2	86	+ 1
37	+ 3	87	+ 1
38	+ 2	88	+ 3
39	+ 1	89	− 1
40	+ 2	90	+ 1
41	+ 1	91	0
42	+ 2	92	− 1
43	+ 1	93	+ 1
44	+ 1	94	0
45	+ 1	95	+ 1
46	+ 1	96	+ 1
47	+ 1	97	0
48	+ 1	98	+ 1
49	0	99	0
50	+ 1	100	+ 1*

Graduations.	Errors.	Graduations.	Errors.
0	0.0	0	0.0
1	+ 2.6	1	− 0.5
2	+ 2.4	2	− 2.5
3	+ 2.9	3	− 1.5
4	+ 2.4	4	− 1.1
5	+ 1.1	5	− 1.6
6	+ 0.6	6	+ 0.5
7	+ 1.2	7	− 1.4
8	− 0.5	8	− 0.1
9	+ 1.0	9	− 0.5
10	− 0.6*	10	− 0.0

RELIABILITY.

a and *b* .... 1.0 to 1.5
c and *d* .... 0.2 to 0.3

The total length has not yet been d termined.

*See Foerster's letter of June 20, 1879.

II.—The Decimeter Scale.

[*a*, the tenth mm. graduations; *b*, the mm. graduations.]

Graduations.	Errors.
− 0.1	+ 0.6
0.0	0.0
0.1	+ 0.3
0.2	+ 0.9
0.3	+ 0.4
0.4	+ 0.9
0.5	− 0.1
0.6	+ 0.4
0.7	+ 0.2
0.8	− 0.1
0.9	+ 0.1
1.0	− 0.2
1.1	+ 1.6
Reliability: 0.3 to 0.5$^{\mu}$.	

Graduations.	Errors.	Graduations.	Errors.
0	0.0	50	+ 1.0
1	0.0	51	+ 1.0
2	− 0.5	52	+ 1.0
3	0.0	53	+ 1.0
4	0.0	54	+ 1.5
5	0.0	55	+ 1.0
6	+ 1.5	56	+ 1.0
7	+ 1.0	57	+ 0.5
8	+ 1.0	58	+ 1.5
9	0.0	59	+ 0.5
10	+ 1.0	60	+ 1.0
11	0.0	61	+ 1.5
12	+ 1.0	62	+ 1.0
13	+ 0.5	63	0.0
14	− 0.5	64	+ 1.0
15	− 0.5	65	+ 1.5
16	− 1.5	66	+ 1.0
17	− 1.0	67	+ 1.5
18	− 0.5	68	0.0
19	− 0.5	69	+ 1.0
20	− 0.5	70	+ 1.5
21	− 0.5	71	+ 1.5
22	− 0.5	72	0.0
23	− 0.5	73	+ 0.5
24	− 0.5	74	− 0.5
25	0.0	75	0.0
26	+ 0.5	76	0.0
27	0.0	77	0.0
28	− 0.5	78	0.0
29	− 1.0	79	0.0
30	− 0.5	80	+ 1.0
31	0.0	81	0.0
32	0.0	82	0.0
33	0.0	83	− 0.5
34	− 1.5	84	+ 1.0
35	+ 0.5	85	+ 2.0
36	0.0	86	+ 1.0
37	− 0.5	87	+ 2.0
38	− 1.0	88	+ 2.5
39	+ 0.5	89	+ 0.5
40	0.0	90	+ 1.0
41	0.0	91	0.0
42	0.0	92	− 0.5
43	− 1.0	93	0.0
44	0.0	94	− 1.5
45	+ 2.0	95	0.0
46	+ 0.5	96	0.0
47	0.0	97	+ 1.0
48	+ 0.5	98	0.0
49	+ 1.5	99	− 0.5
50	+ 1.0	100	0.0
Reliability: 0.5 to 1.0$^{\mu}$.			

The total length has not yet been determined.

In the preceding tables the + and — signs show that the value of the space between the zero and the graduation to be considered is greater or less than the nominal proportional value of this space to the whole length indicated by the number of the graduation, by the amount which stands opposite to the number of the graduation and is expressed in thousandths of a mm.

EXAMPLE.

Opposite the cm. mark 7 will be found in the table the figures + 1.2, that is, the interval between the 0 and the 7 cm. mark amounts to 1.2 thousandths parts of a mm. more than .07 of the distance of the 0 mark from the 1000 mm. mark.

The true metric value of each space can only be found when the total lengths and expansion coefficients of the meter and decimeter scales are known.

Berlin, April 16, 1879.

Kaiserliche Normal Eichungs-Kommission.

By order.

Baumann I.

BERLIN, *den* 20. *Juni*, 1879.

In Beantwortung des gefälligen Schreibens vom 12. v. Mts. und im Anschluss an das diesseitige Schreiben vom 16. April d. J., theilt die Kommission Ihnen hierdurch ergebenst mit dass sich für das Ihnen gehörige stählerne Normalmeter von Repsold (R. 1876) auf Grund der gesetzlichen Beziehungen, welche zwischen unserm Platinmeter und dem metrischen Urmaass angenommen sind, nunmehr folgende Gleichung ergeben hat in welcher t in Centigraden ausgedrückt ist:

$$1 \text{ R. } 1876 = 1 \text{ meter} + 248^{\mu}.89 \pm 0\ .25 + (10^{\mu}.31 \pm 0^{\mu}.034)\ (t^{\circ} - 15^{\circ})$$

Ausserdem liegt eine vorläufige Berechnung der Vergleichungen eines dem Ihrigen vollständig entsprechenden stählernen Normalmeters von Repsold mit einer gutbestimmten Kopie der Bessel'schen Toise vor, aus welcher sich unter der Annahme, dass das metrische Urmaass die bekannte Beziehung zu der durch die Bessel'sche Toise vertretenen altfranzösischen Einheit hat, für Ihr Normalmeter folgende Gleichung in altfranzösischem Metermaass ergeben würde:

$$2 \text{ R. } 1876 = 1 \text{ meter} + 245^{\mu}.6 + 10^{\mu}.31\ (t^{\circ} - 15^{\circ})$$

Beide Gleichungen dürften noch um mehrere Tausend Theile des Millimeter unsicher sein, da in Gleichung 1 die sehr unsichere Vergleichung unsers Urmaasses mit dem Mètre des Archives, in der Gleichung 2 dagegen die Unsicherheit der Beziehungen zwischen der Bessel'schen Toise und der Toise du Pérou, sowie zwischen letzterer und dem Mètre des Archives enthalten ist. Indessen dürfte doch wohl auf 0.01 mm. sicher anzunehmen sein:

$$\text{R. } 1876 = 1 \text{ meter} + 247^{\mu} + 10^{\mu}.31\ (t^{\circ} - 15^{\circ}.0.)$$

Die absolute Länge Ihres *Decimeterstabes* ist leider nicht ausreichend diesseits bestimmt worden, wenigstens nicht entfernt mit derjenigen Schärfe, mit welcher die *Eintheilungsfehler* dieser Hülfsskale ermittelt worden sind. Wir bedauern dies und müssen Ihnen daher anheimgeben, die absolute Länge dieser Skale durch Vergleichung mit einem der Decimeter Intervalle Ihres Normalmeters ermitteln zu wollen, welche durch die obige Angabe der absoluten Länge des ganzen Stabes in Verbindung mit den in dem Schreiben vom 16. April Ihnen mitgetheilten Bestimmungen der inneren Eintheilungsfehler mit entsprechender Zuverlässigkeit angegeben werden können. Wir behalten uns vor, Ihnen demnächst weitere Mittheilungen betreffend Ihren Pendelmaassstab zu senden und die Liquidationsangelegenheit danach entsprechend zu regeln.

Zu dem unter dem 16. April d. J. gesandten Fehlerverzeichniss sind folgende Verbesserungen nachzutragen:

$$\text{R. } 1876 \begin{cases} \text{Theilungsfehler bei } 100^{mm} - 1^{\mu} \text{ statt} + 1^{\mu} \\ \text{Theilungsfehler bei } 10^{cm} - 0.5 \text{ statt} - 0.6 \end{cases}$$

Ausserdem wird bemerkt dass in dem Theilungsfehler-Verzeichnisse der Decimeterskale die Fehler der Millimeter auf $0^{\mu}.5$ abgerundet sind, während diejenigen der Zehntelmillimeter in $0^{\mu}.1$ angegeben werden konnten, und dass hierauf die scheinbare Verschiedenheit der für den 1 mm-Strich in den beiden Reihen angegebenen Fehler zurückzuführen ist.

Kaiserliche Normal Eichungs-Kommission.
FOERSTER.

To the OFFICE OF U. S. LAKE SURVEY,
Detroit, Mich.

[Translation.]

BERLIN, *June* 20, 1879.

In answer to your kind letter of the 12th of last month, and in connection with our letter of April 16 of this year, the Commission has the honor to inform you that your steel standard meter (R. 1876), on the basis of the legal relations which have been taken between our platinum meter and the metrical standard, has the following equation, in which t expressed in centigrade:

$$1)\ \text{R. } 1876 = 1^{m} + 248^{\mu}.89 \pm 0^{\mu}.25 + (10^{\mu}.31 \pm 0^{\mu}.034)\ (t^{\circ} - 15^{\circ})$$

A preliminary computation of the comparisons of a steel standard meter by Repsold perfectly corresponding with yours, with a well-determined copy of Bessel's toise, from which, under the assumption that the metrical standard has the known relation to the old French unit represented by the Bessel toise, would give for your standard meter the following equation in old French meter-measure:

$$2)\ \text{R. } 1876 = 1^{m} + 245^{\mu}.6 + 10^{\mu}.31\ (t^{\circ} - 15^{\circ})$$

Both equations are to be regarded as uncertain by several thousandths of a millimeter, since in equation 1 is contained the very uncertain comparison of our original measure with the meter of the Archives, and in equation 2 the uncertainty of the relations between the Bessel toise and the toise of Peru, as also between the last and the meter of the Archives.

We may, however, certainly assume within $0^{mm}.010$

$$\text{R. } 1876 = 1^{m} + 247^{\mu} + 10^{\mu}.31\ (t^{\circ} - 15^{\circ})$$

The absolute length of your decimeter-bar has unfortunately not been determined sufficiently here, at least not nearly with the same precision with which the graduation errors of this auxiliary scale have been determined. We regret this, and must therefore leave it to you to determine the absolute length of this scale by comparison with one of the decimeter spaces of your standard meter, which, by the absolute length given above of the whole bar, in connection with the determination of the inner graduation errors, transmitted to you in our letter of April 16, can be given with corresponding precision.

We reserve sending to you further communications regarding your pendulum, and also the expense account.

To the list of errors sent April 16 of this year the following corrections are to be carried in:

$$\text{R. } 1876 \begin{cases} \text{Graduation error } 100^{mm} - 1^{\mu} \text{ instead of } + 1^{\mu} \\ \text{Graduation error } 0^{cm} - 0.5 \text{ instead of } - 0.6 \end{cases}$$

Besides, we may remark that in the list of graduation errors of the decimeter scale the errors of the millimeter are rounded to $0^{\mu}.5$, while those of the tenth millimeter can be taken to $0^{\mu}.1$, and that therefore the apparent difference of the errors given in the two series for the 1^{mm} mark is to be attributed to this.

Kaiserliche Normal Eichungs-Kommission.

FOERSTER.

APPENDIX No. 2.

COMPARISON OF LAKE SURVEY THERMOMETER (CASELLA 21472), BY PROFESSOR H. A. ROWLAND AND MR. W. W. JACQUES, OF JOHNS HOPKINS UNIVERSITY, BALTIMORE.

BALTIMORE, *March* 8, 1880.

DEAR SIR: I shall have to apologize for keeping your thermometer so long, but we have been unable to get good results in the horizontal position, and we have about come to the conclusion that the thermometer is of no value in that position, as it seems to require the weight of the mercury to bring the column back to its exact position. Besides, the thermometer is only graduated to $\frac{1}{2}^{\circ}$ F., and the tube is too large, so that very accurate reading is out of the question.

Our standards generally agree to $\frac{1}{50}$ degree, and we can read them with accuracy to that amount or less. I send one of my papers, with a description of our standards.

The best comparisons in the horizontal gave as follows:

Temperature by 6163 in vertical position.	Casella in horizontal position.	Difference.
32°.00 F.	32°.10 F.	.10
44°.94 F.	45°.22 F.	.28
61°.79 F.	62°.47 F.	.68

But these can hardly be relied upon to less than $\frac{1}{10}^{\circ}$. The bulb at the top of the Casella is so small that it is impossible to free the mercury in the bulb from air bubbles, and I always condemn the Casella thermometers on that account. A better maker is Baudin, 276 Rue St. Jacques, Paris, and I would advise you to get some thermometers there and send them here to be compared. But I am not certain whether there are any thermometers which are of use in the horizontal position.

Yours, truly,

H. A. ROWLAND.

General C. B. COMSTOCK.

P. S.—I will send your thermometer immediately, unless you telegraph that you wish us to try further.

COPY OF ORIGINAL READINGS.

Vertical position.

November 4.

6163.	21472.	6165.
(*)	(*)	(*)
124.2	45.33	117.8
124.2—	45.34	117.8
124.2	45.33	117.8
124.2	45.33	117.8
124.2	45.33	117.8
208.1	62.22	227.3+
208.0	62.23	227.3
208.8	62.27	228.0
208.8	62.28	228.0+
208.4	62.25	227.7
273.8	75.27	314.0—
273.8	75.27	314.0
274.2—	75.31	314.4
274.2	75.32	314.5
274.0	75.29+	314.2+
349.5	90.35	418.5
349.5	90.35	418.5
348.5+	90.20	417.0
348.5+	90.20+	417.0
349.0	90.27	417.7

November 6.

6163.	21472.	6165.
58.8	32.07	35.7
58.8	32.07	35.7
58.8—	32.06	35.7
58.8	32.07	35.7
58.8	32.07	35.7
125.0	45.49	119.0—
125.0—	45.49	119.0
125.8	45.63	120.0
125.8+	45.63	120.0
125.4	45.56	119.5
208.1	62.24	227.4
208.1	62.24	227.4
208.7	62.33	228.0
208.7	62.33	228.0
208.4	62.29	227.7
271.7—	74.88	311.0—
271.7	74.88	311.0
271.7+	74.88	311.0
271.8	74.88	311.1
271.7+	74.88	311.0
349.8	90.42	419.0
349.8	90.43	419.0
349.7	90.41	418.9
349.7	90.41	418.9
349.7+	90.42	418.9+

November 7.

6163.	21472.	6165.
58.8 —	32.06	35.6
58.7 +	32.06	35.6—
58.8 —	32.06	35.6—
58.7	32.06	35.6—
58.7 +	32.06	35.6
58.7	32.06	35.6—
58.6 +	32.06	35.6—
58.7 —	32.05+	35.5+
58.7	32.06	35.6
123.0—	45.05	116.1
123.0—	45.06	116.0+
123.0—	45.06	116.1
123.0—	45.06	116.1
126.2	45.76	120.5
126.2	45.76	120.5
126.4	45.86	120.9
126.5	45.88	120.9
124.7	45.43	118.4
208.7—	62.35	228.0—
208.7	62.35	228.0
208.7	62.36	228.0
208.7	62,36	228.0
208.9	62.40	228.4—
209.0—	62.40+	228.4
208.9+	62.40+	228.4
209.0	62.40+	228.4
208.8+	62.37+	228.2
275.1—	75.58	315.9+
275.1	75.58	315.9+
275.1	75.58	316.0—
275.1+	75.58	316.0—
276.0	75.75	317.0
276.0	75.76	317.0
276.0	75.76	317.0
276.0+	75.77	317.0+
275.6	75.67	316.5
349.3+	90.32	418.2
349.3	90.31	418.2
349.3	90.32	418.2
349.3—	90.31	418.2
348.9	90.21	417.5
348.9	90.21	417.5
348.9—	90.20	417.5
348.8+	90.20	417.5
349.1	90.27	417.8+

November 10 and 11.

6163.	21472.	6165.
58.6+	32.04	35.6—
58.6	32.03	35.5
58.6—	32.04	35.5
58.6	32.04	35.5—
58.7—	32.05	35.5
58.6	32.04	35.5
58.6	32.04	35.5
58.6	32.05	35.5
58.6	32.04	35.5
121.8	44.78	114.7
121.8	44.78	114.8
121.8	44.78	114.8
121.8	44.79	114.8
123.6	45.22	117.1
123.6	45.22	117.1
123.6	45.22	117.1
123.5+	45.22	117.1
122.7	45.00	115.9
205.9	61.76	224.7
206.0	61.78	224.8
206.0	61.79	224.8
206.1—	61.79	224.8
206.9	61.97	225.8
206.9	61.98	225.8
206.9	61.98	225.8
206.9	61.98	225.8
206.4	61.88	225.0
271.2+	74.80	310.7
271.3—	74.80	310.7
271.3	74.81	310.7
271.3	74.81	310.7
271.2+	74.80	310.6+
271.3—	74.80	310.6+
271.3	74.81	310.6+
271.3	74.81	310.7—
271.3	74.80	310.7
348.0	90.05	416.8
348.1	90.05	416.8
348.1	90.06	416.8
348.1	90.06	416.8
347.6+	89.98	416.0
347.6	89.99	416.0—
347.6	89.99	416.0
347.6—	89.98	416.0—
347.8	90.02	416.4

* Reading in ice rejected.

The thermometers were placed in the comparator in the order indicated by the columns. Readings were taken from left to right and then right to left. Between each two sets of readings the water in the comparator was slightly stirred.

Vertical position.

	Readings.		Temperatures.		Temperatures corrected.		Mean 6163 twice the weight of 6165.	Mean reduced to ° F.	Reading of 21472.	Difference.
	6163.	6165.	6163.	6165.	6163.	6165.				
	124.2	117.8	7.425	7.402	7.346	7.338	7.343	45.22	45.33	.11
November 4	208.4	227.7	16.850	16.819	16.771	16.755	16.766	62.18	62.25	.07
	274.0	314.2	24.101	24.082	24.022	24.018	24.021	75.24	75.29	.05
	349.0	417.7	32.403	32.379	32.324	32.315	32.321	90.18	90.27	.09
	58.8	35.7	.079	.064	0	0	0	32.0	32.07	.07
	125.4	119.5	7.560	7.551	7.481	7.487	7.483	45.47	45.56	.09
November 6.......	208.4	227.7	16.850	16.819	16.771	16.755	16.766	62.18	62.29	.11
	271.7	311.0	23.849	23.822	23.770	23.758	23.766	74.79	74.88	.09
	349.7	418.9	32.481	32.486	32.402	32.422	32.409	90.34	90.42	.08
	58.7	35.6	.068	.055	0	0	0	32.0	32.06	.06
	124.7	118.4	7.481	7.455	7.413	7.400	7.409	45.34	45.43	.09
November 7.......	208.8	228.2	16.895	16.862	16.827	16.807	16.820	62.28	62.37	.09
	275.6	316.5	24.277	24.271	24.209	24.216	24.211	75.58	75.67	.09
	349.1	417.8	32.414	32.386	32.346	32.331	32.341	90.21	90.26	.05
	58.6	35.5	0.57	.046	0	0	0	32.00	32.04	.04
	122.7	115.9	7.258	7.236	7.201	7.190	7.197	44.95	45.00	.05
November 10, 11..	206.4	225.0	16.628	16.589	16.571	16.543	16.562	61.81	61.88	.07
	271.3	310.7	23.805	23.797	23.748	23.751	23.749	74.75	74.80	.05
	347.8	416.4	32.269	32.284	32.212	32.238	32.221	90.00	90.02	.02

As the rise in temperature is so small, a day was considered sufficient for the return of the zero point, though our standard seems to have lowered somewhat. But the error is small, at most.

6163 is best standard. We therefore give these observations twice the weight of those of 6165.

The mean errors are then—

Mean error of 21472, as compared with the absolute thermometer, is:

At 32° F.	+0.06 F.
45°	.08
62°	.08+
75°	.07+
90°	.06

The above are the errors of the thermometer when in a vertical position.

JOHNS HOPKINS UNIVERSITY,
Baltimore, January 30, 1880.

DEAR SIR: Inclosed please find four independent comparisons of your Casella 21472 with our standards, *in a vertical position*. I have made several attempts, and in different ways, to obtain a correction for the horizontal position, but find it useless, from the fact that your thermometer, although always at exactly the same temperature, will never read twice the same when laid in a horizontal position. The difference at 90° may be as much as half a degree.

The error is probably due to an air bubble in the bulb, which in a Casella thermometer it is impossible to remove.

The thermometer is only accurate when used in a vertical position, but it is then, as you may see from the inclosed results, very accurate, indeed, when compared with the air thermometer.

Trusting that the results I send will prove satisfactory, I am,

Yours, very truly,

W. W. JACQUES,
Late Fellow in Physics, J. H. U.

C. B. COMSTOCK,
Bvt. Brig. General, U. S. A.

BALTIMORE, *March* 27, 1880.

DEAR SIR: I am sorry you have discovered any arithmetical error in the tables I sent you, but it arose from my having sent off the tables before any final check on them. They were in my study some time, waiting for the comparison in the horizontal position and I forgot that they had not been verified.

The systematic error you speak of comes from our using a different value for the "M" in the formula of reduction to the air thermometer. The published table was computed from the mean value of M as obtained by direct observation and by comparison with a thermometer, No. 6167, see p. 111. But on making more observations I rejected the result from No. 6167, and returned to the value M=.00015 as I had before found directly. See bottom of page 119. In Table LIII you will find the corrections by comparing the first two columns. The correction must be added, and amounts to $\frac{1}{100}$° C. at 20°.*

I took your thermometer in hand myself at last, and have got some very good results in the horizontal position. I send two comparisons, the first of which was made by Mr. Koyl and myself together, and the second by Mr. Koyl alone.

I succeeded after some time in getting the air bubble safely out of the bulb, which accounts for our getting better results. It could hardly be seen by the naked eye, and could not have influenced the comparison in the verical position much.

The comparison was made in a copper vessel holding about one gallon, as in the drawing. The bulbs were close together. Thermometers were tied to the stems of each to indicate the temperature of the protruding mercury column. This varied considerably on account of the lamp used to heat the water, but the calculated correction is always very small, as our thermometer has to be vertical and the other horizontal, it is difficult without a special apparatus to make an exact comparison with the stems wholly immersed. I also compared the vertical with the horizontal readings by putting the thermometer in a small vessel of water, which was covered with a cloth to prevent cooling. The thermometer was then quickly turned from one position to the other and readings made. It was also turned completely over, so as to get twice the effect. In reducing these observations it is probably best to assume that the effect is proportional to the distance of the mercury above the bulb, as the 15°-point came about at the bulb we can write approximately—

$$\triangle = c\,(t-15^\circ).$$

We can then compute c from the different observations. From the observations which I sent, I have computed c roughly and without verification to be as follows:

No. of series.	Weight.	C.
1	1	.0017
2	2	.0018
3	3	.0014
4	1	.0017
5	3	.0013
6	5	.0016
7	3	.0015
	Mean=	.0015

From which I find the following—

Temp. 32°	0°.026 F.
45°	0°.045
62°	0°.071
75°	0°.090
90°	0°.113

which, however, should be recomputed.

I will tell Mr. Jacques and Mr. Koyl to send their bills, and hope that the various observations will agree when worked up, though the thermometer does not read close enough for the highest accuracy.

Yours truly,

H. A. ROWLAND,

General C. B. COMSTOCK.

* See Mechanical Equivalent of Heat by Henry A. Rowland, Prof. of Physics, Johns Hopkins University. Cambridge, 1880.

COMPARISON OF CASELLA, NO. 21472, WITH BAUDIN, NO. 6163.

March 16, 1880.

1.		2.		3.		4.		5.		6.	
Casella.	Baudin.	Casella.	Baudin.	Casella.	Baudin.	Casella.	Baudin.	Casella.	Baudin.	Casella.	Baudin.
In ice.				Casella in water to 40° mark; Baudin to 100.mm mark.							
Vert.		*Horiz.*	*mm.*	*Horiz.*	*mm.*	*Horiz.*	*mm.*	*Horiz.*	*mm.*	*Horiz.*	
32.075	58.90	32.150	58.95	52.55	159.80	62.90	211.20	....	....	90.00	347.7
32.100	58.85	32.125	59.00	52.60	160.00	63.10	212.00	75.00	272.1	90.25	348.7
32.075	58.96	32.130	58.95	53.10	162.30	63.35	213.40	75.30	273.40	90.35	349.2
32.100	58.95	32.140	58.96	53.14	162.70	63.35	213.50	75.45	274.2	90.40	349.6
32.068	Means....	32.136	58.94	53.80	165.80	63.45	214.00	75.50	274.5	90.45	349.7
				53.85	166.00	63.50	214.30	75.55	274.8	90.45	349.7
			Mean.....	53.178	162.77	63.56	214.30	75.60	275.0	90.45	349.7
						63.55	214.50	75.60	274.9	90.70	350.5
										90.70	350.5
					Means...	63.338	213.40	75.429	274.13		
									Means......	90.417	349.48
				Stem temp. 19°.5 C.	Stem at 20°.5	Stem at 24°.0	Stem at 24°.0	Stem at 27°.0	Stem at 29°.0	Stem at 31°.0	Stem at 30°.0

NOTE.—Readings by Rowland.

Means of preceding.

1. Casella original.	2. Stem. Temp. C.	2. Stem. Correction.	3. Corrected reading.	4. Baudin original.	5. Stem. Temp. C.	5. Stem. Correction.	6. Corrected reading.	7. Absol. temp. cent. M =.00015.	8. Temp. from 0° Fahr.	Δ or correction to absol. sc. of col. 3.
° v.	°	n.	° v.	mm.	°			°	°	° v.
32.088	0	.0	32.088	58.94	0	.0	....	....	....	—.088
h.			h.							h.
32.136	0	.0	32.136	58.94	0	.0	58.94	0.0	32.000	—.136
		° Fahr.				mm.				
53.173	19.5	—0.017	53.156	162.77	20.5	—.080	162.69	11.646	52.963	—.193
63.338	24.0	—0.026	63.312	213.40	24.0	—.127	213.27	17.296	63.183	—.179
75.429	27.0	—0.017	75.412	274.13	28.0	—.111	274.02	24.008	75.214	—.198
90.417	30.0	+0.019	90.436	349.48	30.0	+.092	349.57	32.371	90.268	—.168

NOTE.—Correct zero reading, or 32°.088 is the only vertical reading; 0°.088 must therefore be subtracted from each to complete the reduction.

KOYL.

CASELLA.

[Experiments to determine the correction for horizontal positions.]

I. Upright.	I. Inverted.	I. Horizontal.	II. Upright.	II. Inverted.	II. Horizontal.	
		Mean of other two.				In this comparison (March 16) readings were made by Professor Rowland; reduction was made by Koyl.
°	°		°	°	°	
72.4	72.55	....	90.225	90.475	....	
72.35	72.575	....	90.125	90.400	....	
72.35	72.55	....	90.063	90.300	....	
72.35	....	....	89.975	90.275	....	
72.363	72.558	72°.461	89.900	90.200	....	
Δ=	—.195	—°.098	90.056	90.330	90.193	
			Δ=	—0.274	—0.137 F.	

Second comparison, March 18, 1880. Readings and reduction by Koyl.

No.	Casella.	Stem.	Baudin.	Stem.
	°		mm.	
	Vert. in ice.			
1	32.10	0°.0	58.95	0°.0
	32.10		58.90	
	32.08		58.85	
	32.10		58.85	
	Hor. in ice.			
2	32.15	0°.0	58.85	0°.0
	32.20		58.80	
	32.15		58.80	
	32.15		58.83	
3	51.95	22°.C.	156.7	22°.5
	52.00		156.8	
	52.05		157.08	
	52.06		157.3	
	52.10		157.7	
	52.20		157.85	
4	52.23	21°—	158.0	21°—
	52.30		158.3	
	52.30		158.4	
	52.32		158.4	
	52.40		158.7	
	52.36		158.8	
	°		mm.	
5	61.70	25°	205.15	24°
	62.00		206.30	
	62.22		208.10	
	62.45		208.95	
	62.70		208.95	
6	62.47	23°	208.70	22°
	62.48		208.80	
	62.50		208.90	
	62.52		209.15	
	62.55		209.30	
	62.55		209.80	
7	62.53	22°	209.25	22°
	62.52		209.40	
	62.52		209.50	
	62.56		209.50	
8	75.55	23°	274.6	23°
	75.58		274.7	
	75.56		274.9	
	75.58		275.0	
	75.58		274.8	
	°		mm.	
9	75.52	23°	274.4	23°
	75.47		273.92	
	75.46		273.95	
	75.47		273.90	
	75.45		273.85	
	75.35		273.30	
	75.30		273.20	
10	90.96	25°.5	352.40	25°.5
	91.03		352.25	
	91.04		352.50	
	91.05		352.95	
	91.10		353.10	
11	91.06	24°.0	352.20	24°.0
	91.00		352.20	
	91.00		352.10	
	90.94		352.00	
	90.80		351.00	
	90.80		350.95	
	90.80		350.92	

In experiments 1 to 7, inclusive, Casella in water to 45°, and Baudin in water to 100mm. After experiment 7, Casella as before; Baudin in water to 110mm.

Means of preceding.

Exp.	Casella original.	Stem. Temp. C.	Stem. Correction.	Corrected reading.	Baudin original.	Stem. Temp. C.	Stem. Correction.	Corrected reading.	Absolute temp. from 0° C., m=.00015.	Absolute temp. from 0° Fahr.	Δ or correction of column 5 to absol. sc.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
	° v.	°	° F.	° v.	mm.	°	mm.	°	°	°	° v.
1	32.095	0	0	32.095	58.84	0	0	58.84	0	32.000	−.095
	° h.			° h.							° h.
2	32.162	0	0	32.162	58.84	0	0	58.84	0	32.000	−.162
3	56.060	22	−.013	52.047	157.238	22.5	−.105	157.133	11.037	51.867	−.180
4	52.318	21	−.012	52.306	158.433	21.0	−.093	158.340	11.171	52.108	−.198
5	62.214	25	−.022	62.192	207.490	24.0	−.120	207.370	16.653	61.975	−.217
6	62.512	23	−.016	62.496	209.110	22.0	−.087	209.023	16.837	62.307	−.189
7	62.532	22	−.014	62.518	209.412	22.0	−.087	209.325	16.871	62.368	−.150
8	75.570	23	+.005	75.575	274.800	23.0	+.027	274.827	24.110	75.398	−.177
9	75.432	23	+.005	75.437	273.789	23.0	+.026	273.815	23.998	75.196	−.241
10	91.036	25.5	+.052	91.088	352.640	25.5	+.272	352.912	32.756	90.961	−.127
11	90.914	24	+.063	90.977	351.624	24.0	+.329	351.953	32.649	90.768	−.209

Allowing each, in table above, equal weight.				Rejecting Nos. 9 and 11, in which the mercury had begun to contract.				
Exp.	Casella.	Baudin.	Δ	Exp.	Casella.	Baudin.	Δ	
	° v.	°	°		° v.	°	°	°
1	32.095	32.000	−.095	1	32.095	32.000	−.095	−.10
	° h.				° h.			
2	32.162	32.000	−.162	2	32.162	32.000	−.162	−.16
3–4	52.177	51.988	−.189	3–4	52.177	51.988	−.189	−.19
5–7	62.402	62.217	−.185	5–7	62.402	62.217	−.185	−.19
8–9	75.506	75.297	−.209	8	75.575	75.398	−.177	−.18
10–11	91.033	90.865	−.168	10	91.088	90.961	−.127	−.13

All readings horizontal except those for vertical zero point 32°.095.

NOTE.—When the temperature falls with the thermometer in the horizontal position the mercury seems to be left behind, as is seen on comparing 8 and 9, and 10 and 11. This was much greater before the removal of the air-bubble. For the backward motion of the mercury, its weight seems to be necessary; hence I never use a thermometer in the horizontal position.—H. A. R.

CASELLA 21472.

Experiment to determine the correction for horizontal position.

[Readings by Professor Rowland. Reduction by Koyl.]

III.		IV.		V.		VI.		VII.	
Upright.	Reversed.	Upright.	Horizontal.	Upright.	Reversed.	Upright.	Reversed.	Upright.	Horizontal.
100.75	101.00	100.00	100.25	99.90	100.15	97.05	97.35	96.75	96.85
.75	100.95	.10	.20	.85	.15	.05	.30	.75	.85
.70	.85	.05	.20	.85	.10	.00	.30	.70	.85
.65	.85	.05	.20	.85	.05	.00	.30	.70	.85
.60	.80	.00	.20	.85	.05	.00	.25	.70	.85
.50	.70	.00	.15	.80	.00	.00	.25	.65	.75
.45	.65	.00	.15	.75	99.95	.00	.25	.60	.70
.40	.65	.00	.10	.75	.95	96.95	.20	.60	.70
.35	.60	99.95	....	.75	.95	.95	.20	.55	.65
.35	.55			.70	.90	.95	.15	.55	.65
.30	.50			.70	....	.90	.15	.50	.60
.30	.50					.85	.15	.50	.60
.20	.45					.85	.15	.50	.60
.15	....					.85	.10	.50	.60
						.85	.10	.45	.55
						.85	.10	.45	.55
						.85	.10	.45	.55
						.80	.05	.40	.55
						.80	.00	.40	.50
						.80	.00	.35	.50
						.80	....	.35	....
100.46	100.70	100.03	100.18	99.795	100.025	96.912	97.173	96.548	96.665
Δ = −0°.24 F. ÷ 2		Δ = −0°.15 F.		Δ = −0°.230 ÷ 2		Δ = −0°.261 ÷ 2		Δ = −°.122	
Δ = −0°.12 F.				Δ = −0°.115 F.		Δ = −0°.130 F.			

Exp.	Temp.	Correction.	Weight of observ.
	°	° F.	
I	72.5	−0.098	1
II	90.2	−0.187	2
III	100.7	−0.120	3
IV	100.2	−0.150	3
V	100.0	−0.115	1
VI	97.2	−0.130	5
VII	96.5	−0.122	3

APPENDIX No. 3.

LONGITUDE AND LATITUDE.

1. REPORT UPON OBSERVATIONS FOR LONGITUDE OF OLNEY, ILLINOIS, BY CAPTAIN D. W. LOCKWOOD, CORPS OF ENGINEERS.

DETROIT, MICH., *February* 14, 1880.

SIR: I have the honor to make the following report on the determination of the difference of longitude between Detroit Mich., and Olney, Ill.

This determination was made in compliance with the following order:

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., July 8, 1879.

SIR: First Lieuts. D. W. Lockwood and P. M. Price will determine the difference of longitude, telegraphically, between Detroit and Olney, Ill., Lieutenant Price observing at the latter place. Signals will be exchanged on four nights with good time determinations on each night. Stars will be selected from American Ephemeris, from 539 Sternen, and from the General Bericht for 1870. Fifteen wires will be observed on for time stars and eleven will be reduced. For slow stars not less than seven wires should be used and eleven when possible.

PROGRAMME FOR TIME DETERMINATION.

Level readings.
Circumpolar star reversed on.
Level readings.
Five or more well-determined time stars.
Level readings.
Reversal.
Level readings.
Five or more well-determined time stars.
Level readings.
Circumpolar star reversed on.
Level readings.

Then will follow the exchange of clock-signals, which will be sent alternately for $1^m\ 20^s$ from each station till two sets have been sent from each station. The observers will carefully adjust the tensions in their relays and request the repeating stations to do the same before sending clock-signals. After exchange of clock-signals, another time determination after the above programme will be made. Chronographs will be used at both stations and a break-circuit chronometer at Olney. * * * Two nights' work with the double programme will be obtained for personal equation, each observer using his own instrument, chronograph, and time-piece, before going into the field, and as many more after returning. Each night's personal equation work will be a complete determination of the difference of longitudes of the two instruments, one in, the other outside of the observatory. Every care will be taken to secure the most accurate work.

Very respectfully,

C. B. COMSTOCK,
Major of Engineers, Brevet Brigadier-General, U. S. A.

First Lieut. D. W. LOCKWOOD,
Corps of Engineers, Detroit, Mich.

The instruments used at the Detroit observatory by myself were Buff & Berger transit No. 2, focal length 39 inches, aperture 3 inches, magnifying power of diagonal eye-piece 87; sidereal clock No. 256, Bond & Sons, and chronograph No. 216 by the same makers.

Lieutenant Price used Wurdemann transit No. 1, focal length 31 inches, aperture 2¼ inches, magnifying power about 100; sidereal break-circuit chronometer 1524 by Negus; and chronograph No. 245 by Bond & Sons.

Throughout the season the Detroit transit was mounted on the east pier (stone) in the lake survey observatory, and while determining relative personal equation, Lieutenant Price's transit was mounted on the stone pier in the yard, a little to the south and west.

Observations to determine relative personal equation before going into the field were made on the nights of July 5 and 8. Signals were interchanged with Lieutenant Price at Olney on the nights of July 26, 28, 29, and 30, and finally, on Lieutenant Price's return from the field, observations to redetermine relative personal equation were made on the nights of August 26 and 27. As far as possible the same stars were observed at each station.

The observations of each night have been reduced by the method of least squares; the hourly rate, clock-error, or rather correction to assumed clock-error, and azimuth being the unknown quantities. The collimation was determined by reversal on close circumpolar stars, those only being taken whose declinations exceeded 80°. In making up the normal equations, a weight unity was given to 11 wires for time stars, and where the number of wires differed from 11, the weight was taken from Table B, report of Capt. H. M. Adams, Corps of Engineers, on telegraphic longitude, 1876-'77, in the annual report of Maj. C. B. Comstock, Corps of Engineers, for the fiscal year ending June 30, 1877. The same formula was used in computing the weights of slow stars as was used by Captain Adams in his work. The probable errors of transit over a single wire for high and low stars were determined from the season's observations.

TABLES APPENDED.

Table 1 gives the results for personal equation.

The clock and chronometer times of comparison are each, with the exception of one night's work, the means of a set of fifteen individual comparisons.

Table 2 gives the difference of longitude between Detroit and Olney, the means of clock and chronometer times of comparisons being derived from sets of fifteen individual results.

The remaining tables give the individual errors for each night's time work, *i. e.*:
First column: Authority or catalogue from which star is taken.
Second column: Name of star.

Third column: Position of telescope.
Fourth column: Azimuth correction.
Fifth column: Level correction.
Sixth column: Collimation, aberration, and reduction to middle wire.
Seventh column: Rate.
Eighth column: Observed time of transit, mean of 11 wires for time stars.
Ninth column: Same corrected for azimuth, level, reduction to middle wire, aberration, and rate.
Tenth column: Right ascension.
Eleventh column: Clock-error as determined by each star.
θ is the assumed clock-error at the (clock) epoch for which the error is determined.
ρ, the hourly rate.
a, azimuth.

Very respectfully, your obedient servant,

D. W. LOCKWOOD,
Captain of Engineers.

Maj. C. B. COMSTOCK,
Corps of Engineers.

TABLE 1.—1879. *Relative personal equation.—Capt. D. W. Lockwood and Lieut. P. M. Price.*

Signals from—	Date.	Clock No. 256—Lockwood, observer. Mean of clock times of comparisons.	Clock corrections.	Means of sidereal times of comparisons.	Chronometer No. 1524—Price, observer. Means of chronometer times of comparisons.	Chronometer corrections.	Means of sidereal times of comparisons.	Difference of time. Signals from clock.	Signals from chronometer.	Means.
	1879.	h. m. s.	s.	h. m. s.	h. m. s.	m. s.	h. m. s.	s.	s.	s.
Clock	July 5	18 27 00.000	+ 9.116	18 27 09.116	18 29 16.390	−2 07.280	18 27 09.110	+ 0.006		
	July 5	18 28 00.000	9.116	18 28 09.116	18 30 16.392	7.282	18 28 09.110	+ 0.006		
	July 5	18 39 00.000	9.118	18 39 09.118	18 41 16.408	7.301	18 39 09.107	+ 0.011		
	July 5	18 40 00.000	9.118	18 40 09.118	18 42 16.407	7.303	18 40 09.104	+ 0.014		
Chronometer	July 5	18 34 43.618	9.117	18 34 52.735	18 37 00.000	7.294	18 34 52.706		+ 0.029	
	July 5	18 35 43.619	9.117	18 35 52.736	18 38 00.000	7.295	18 35 52.705		+ 0.031	
	July 5	18 44 43.615	9.118	18 44 52.733	18 47 00.000	7.311	18 44 52.689		+ 0.044	
	July 5	18 45 43.614	+ 9.118	18 45 52.732	18 48 00.000	−2 07.313	18 45 52.687		+ 0.045	
Means for July 5								+ 0.009	+ 0.037	+ 0.023
Clock	July 8	18 30 00.000	+ 9.188	18 30 09.188	18 32 23.293	−2 14.170	18 30 09.123	+ 0.065		
	July 8	18 31 00.000	9.188	18 31 09.188	18 33 23.289	14.172	18 31 09.117	+ 0.071		
	July 8	18 41 00.000	9.188	18 41 09.188	18 43 23.238	14.188	18 41 09.050	+ 0.038		
	July 8	18 42 00.000	9.188	18 42 09.188	18 44 23.235	14.190	18 42 09.045	+ 0.143		
Chronometer	July 8	18 38 08.799	9.188	18 38 17.987	18 40 32.000	14.183	18 38 17.817		+ 0.170	
	July 8	18 38 36.799	9.188	18 38 45.987	18 41 00.000	14.184	18 38 45.816		+ 0.171	
	July 8	18 46 36.796	9.188	18 46 45.984	18 49 00.000	14.197	18 46 45.803		+ 0.181	
	July 8	18 47 36.796	+ 9.188	18 47 45.984	18 50 00.000	−2 14.199	18 47 45.801		0.183	
Means for July 8								+ 0.104	+ 0.176	+ 0.140
Clock	Aug. 26	20 06 56.000	+ 5.906	20 07 01.906	20 07 32.897	− 30.848	20 07 02.049	0.143		
	Aug. 26	20 07 04.000	5.906	20 07 09.906	20 07 40.900	30.848	20 07 10.052	− 0.146		
	Aug. 26	20 06 41.000	5.906	20 06 46.906	20 07 17.893	30.847	20 06 47.046	− 0.140		
	Aug. 26	20 06 49.000	5.906	20 06 54.906	20 07 25.896	30.848	20 06 55.048	− 0.142		
Chronometer	Aug. 26	20 17 23.146	5.909	20 17 29.055	20 18 00.000	30.868	20 17 29.132		− 0.077	
	Aug. 26	20 18 23.139	5.909	20 18 29.048	20 19 00.000	30.871	20 18 29.129		− 0.081	
	Aug. 26	20 36 23.101	5.914	20 36 29.015	20 37 00.000	30.907	20 36 29.003		− 0.078	
	Aug. 26	20 37 23.099	+ 5.914	20 37 29.013	20 38 00.000	− 30.909	20 37 29.091		− 0.078	
Means for Aug. 26								− 0.143	− 0.078	− 0.110
Clock	Aug. 27	20 18 00.000	+ 6.162	20 18 06.162	20 18 39.245	− 33.004	20 18 06.241	− 0.079		
	Aug. 27	20 19 00.000	6.162	20 19 06.162	20 19 39.235	33.006	20 19 06.229	− 0.067		
	Aug. 27	20 23 00.000	6.163	20 23 06.163	20 23 39.210	33.013	20 23 06.197	− 0.034		
	Aug. 27	20 24 00.000	6.163	20 24 06.163	20 24 39.215	33.015	20 24 06.200	− 0.037		
Chronometer	Aug. 27	20 15 20.804	6.162	20 15 26.966	20 16 00.000	32.999	20 15 27.001		− 0.035	
	Aug. 27	20 16 20.801	6.162	20 16 26.963	20 17 00.000	33.001	20 16 26.999		− 0.036	
	Aug. 27	20 20 20.801	6.163	20 20 26.964	20 21 00.000	33.008	20 20 26.992		− 0.028	
	Aug. 27	20 21 20.800	+ 6.163	20 21 26.963	20 22 00.000	− 33.010	20 21 26.990		− 0.027	
Means for Aug. 27								− 0.054	− 0.032	− 0.043

Mean for July 5 and 8 and for August 26 and 27 .... + 0ˢ.002
Correction for difference of longitude of transit instruments .... − 0ˢ.005
Lockwood observes later than Price .... − 0ˢ.003

TABLE 2.—1879. *Telegraphic longitude Detroit, Mich., and Olney, Ill.*

Signals from—	Date. 1879.	Detroit.—Observer, Captain Lockwood. Means of clock times of comparisons.	Clock corrections.	Means of sidereal times of comparisons.	Olney.—Observer, Lieutenant Price. Means of chronometer times of comparisons.	Chronometer corrections.	Means of sidereal times of comparisons.	Difference of time. Signals from Olney.	Signals from Detroit.	Means.
		h. m. s.	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*h. m. s.*	*m. s.*	*m. s.*	*m. s.*
Olney, Ill	July 26	21 18 39.283	+07.449	21 18 46.732	20 57 30.000	+1 08.149	20 58 38.149	20 08.583	....	
	July 26	21 19 12.285	7.449	21 19 19.734	20 58 03.000	1 08.148	20 59 11.148	08.586	....	
	July 26	21 24 12.277	7.448	21 24 19.725	21 03 03.000	1 08.146	21 04 11.146	08.579	....	
	July 26	21 25 12.277	7.448	21 25 19.725	21 04 03.000	1 08.146	21 05 11.146	20 08.579	....	
Detroit, Mich	July 26	21 14 00.000	7.449	21 14 07.449	20 52 50.887	1 08.150	20 53 59.037	....	20 08.412	
	July 26	21 15 00.000	7.449	21 15 07.449	20 53 50.888	1 08.150	20 54 59.038	....	08.411	
	July 26	21 21 00.000	7.449	21 21 07.449	20 59 50.907	1 08.148	21 00 59.055	....	08.394	
	July 26	21 22 00.000	+07.448	21 22 07.448	21 00 50.904	+1 08.147	21 01 59.051	....	08.397	
Means for July 26								20 08.582	20 08.404	20 08.493
Olney, Ill	July 28	20 40 18.383	+07.201	20 40 25.584	20 21 00.000	−0 43.010	20 20 16.990	20 08.594	....	
	July 28	20 40 35.386	7.201	20 40 42.587	20 21 17.000	43.010	20 20 33.990	08.597	....	
	July 28	20 49 26.377	7.199	20 49 33.576	20 30 08.000	43.021	20 29 14.979	08.597	....	
	July 28	21 03 08.387	7.197	20 03 15.584	20 43 50.000	43.038	20 43 06.962	20 08.622	....	
Detroit, Mich	July 28	20 26 46.000	7.203	20 26 53.203	20 07 27.791	42.994	20 06 44.797	....	20 08.406	
	July 28	20 46 00.000	7.200	20 46 07.200	20 26 41.817	43.017	20 25 58.800	....	08.400	
	July 28	20 47 00.000	7.200	20 47 07.200	20 27 41.822	43.018	20 26 58.804	....	08.396	
	July 28	21 18 42.000	+07.194	21 18 49.194	20 59 23.817	−0 43.056	20 58 40.761	....	08.433	
Means for July 28								20 08.602	20 08.409	20 08.505
Olney, Ill	July 29	21 10 25.657	+07.074	21 10 32.731	20 51 08.000	−43.903	20 50 24.097	20 08.634	....	
	July 29	21 10 44.671	7.074	21 10 51.745	20 51 27.000	43.904	20 50 33.096	08.649	....	
	July 29	21 11 25.667	7.074	21 11 32.741	20 52 08.000	43.904	20 51 24.096	08.645	....	
	July 29	21 11 44.673	7.074	21 11 51.747	20 52 27.000	43.904	20 51 33.096	08.651	....	
Detroit, Mich	July 29	20 46 27.000	7.074	20 46 34.074	20 27 09.523	43.884	20 26 25.639	....	20 08.435	
	July 29	20 47 00.000	7.074	20 47 07.074	20 27 42.539	43.884	20 26 58.655	....	08.419	
	July 29	21 23 00.000	7.073	21 23 07.073	21 03 42.591	43.913	21 02 58.678	....	08.395	
	July 29	21 24 00.000	+07.073	21 24 07.073	21 04 42.597	−43.914	21 03 58.683	....	08.390	
Means for July 29								20 08.645	20 08.410	20 08.527
Olney, Ill	**July 30**	22 03 17.000	+06.965	22 03 23.965	21 44 00.000	−44.554	21 43 15.446	20 08.519	....	
	July 30	23 04 17.000	6.965	22 04 23.965	21 46 00.000	44.555	21 44 15.445	08.520	....	
	July 30	21 17 17.000	6.973	21 17 23.973	20 58 00.000	44.502	20 59 15.498	08.475	....	
	July 30	21 18 17.000	6.973	21 18 23.973	20 59 00.000	44.503	20 58 15.497	08.476	....	

Detroit, Mich	July 30	21 14 00.000	6.974	21 14 06.974	20 54 43.176	44.499	20 53 58.677		20 08.297		
	July 30	21 15 00.000	6.974	21 15 06.974	20 55 43.177	44.500	20 54 58.677		08.297		
	July 30	22 09 31.000	6.964	22 09 37.964	21 50 14.205	44.560	21 49 29.645		08.319		
	July 30	22 23 31.000	06.962	22 23 37.962	22 04 14.220	44.576	22 03 29.644		08.318		
Means for July 30								20 08.498	20 08.308	20 08.403	

	m. s.
Means for July 26, 28, 29, and 30	20 08.482
Relation personal equation, Lockwood – Price	+00.003
Olney, Ill., west of Detroit, Mich	20 08.485

TABLE 3.—*Detroit time, July 5, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δi + ab)	R ρ	T′, obsd. time.			T, corr. time.	Right ascension.			ΔT
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
G.B.	Carr. 580 L. C	......	− 0.79	....	....	− 0.02	16	00	......	....	4	00	19.91	......
A.	ζ Ophiuchi	D.	− 0.09	0.01	+ 0.02	− 0.02		30	24.58	24.48	16	30	33.66	9.18
G.	ζ Herculis	D.	− 0.02	− 0.02	+ 0.03	− 0.01		36	37.63	37.61		36	46.80	9.19
A.	η Herculis	D.	− 0.01	− 0.03	+ 0.03	− 0.01		38	38.96	38.94		38	48.12	9.18
G.	49 Herculis	D.	− 0.05	− 0.01	+ 0.02	− 0.01		46	28.77	28.72		46	37.83	9.11
A.	κ Ophiuchi	D.	− 0.06	− 0.01	+ 0.02	− 0.01		51	50.94	50.88		51	59.98	9.10
G.	ε Herculis	D.	− 0.02	− 0.01	+ 0.03	− 0.01		55	33.88	33.87		55	42.95	9.08
A.	α Ophiuchi	R.	− 0.06	− 0.01	− 0.06	− 0.01	17	29	13.65	13.51	17	29	22.67	9.16
G.	β Ophiuchi	R.	− 0.07	− 0.01	− 0.06	− 0.01		37	24.49	24.34		37	33.44	9.10
G.	γ Ophiuchi	R.	− 0.07	− 0.02	− 0.06	− 0.01		41	44.36	44.20		41	53.30	9.10
G.	θ Herculis	R.	− 0.01	− 0.03	− 0.07	− 0.01		52	00.68	00.56		52	09.54	8.98
G.	67 Ophiuchi	R.	− 0.07	− 0.02	− 0.06	− 0.01		54	29.96	29.80		54	38.94	9.14
G.	72 Ophiuchi	R.	− 0.06	− 0.03	− 0.06	− 0.01	18	01	31.50	31.34	18	01	40.47	9.13
A.	δ Urs. Min	......	+ 1.20	....	....	− 0.00		11	......	....		11	27.85	......
A.	λ Urs. Min	......	+ 4.32	....	....	+ 0.00	19	45	......	....	19	45	26.99	......
G.	θ Aquilæ	R.	− 0.07	− 0.00	− 6.74	+ 0.01	20	05	05.19	58.39	20	05	07.49	9.10
A.	α² Capricorni	R.	− 0.09	− 0.00	− 0.06	+ 0.01		11	15.55	15.41		11	24.47	9.06
G.	γ Cygni	R.	− 0.01	− 0.01	− 0.07	+ 0.01		17	47.39	47.31		17	56.48	9.17
A.	π Capricorni	R.	− 0.10	− 0.01	− 0.06	+ 0.01		20	18.80	18.73		20	27.85	9.12
A.	ε Delphini	R.	− 0.06	− 0.01	− 0.06	+ 0.01		27	20.58	20.46		27	29.50	9.04
G.	α Delphini	R.	− 0.05	− 0.02	− 0.06	+ 0.01		33	55.47	55.35		34	04.58	9.23
G.	γ² Delphini	D.	− 0.05	− 0.03	+ 0.02	+ 0.01		40	56.96	56.91		41	06.18	9.27
A.	μ Aquarii	D.	− 0.09	− 0.01	+ 0.02	+ 0.01		46	02.53	02.46		46	11.45	8.99
A.	ν Cygni	D.	− 0.00	− 0.01	+ 0.03	+ 0.01		52	33.88	33.91		52	42.98	9.07
A.	61¹ Cygni	D.	− 0.01	− 0.00	+ 0.03	+ 0.01	21	01	22.73	22.76	21	01	31.93	9.17
A.	ζ Cygni	D.	− 0.03	− 0.00	+ 0.03	+ 0.01		07	41.36	41.37		07	50.49	9.12
A.	1 Draconis L. C	......	− 0.64	....	....	......	21	19	......	....	9	19	43.51	......

$\theta + \delta\theta = +9^s.120$ = clock-error at 19^h clock-time.
$\rho = +0^s.007$ = hourly rate (losing).

NORMAL EQUATIONS.

$$-3.60\,\delta\theta - 1.91\,a + 60.48\,\rho + 0.1 = 0$$
$$+10.83\,\delta\theta + 11.99\,a - 1.91\,\rho - 1.02 = 0$$
$$+23.065\,\delta\theta + 10.83\,a - 3.60\,\rho - 3.88 = 0$$

$\delta\theta = 0^s.120 \qquad a = -0^s.11 \qquad \rho = +0^s.007$

TABLE 4.—*Detroit time, July 8, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	$A\,a$	$B\,b$	$C\,(c+\Delta i+a\,b)$	$R\,\rho$	T', obsd. time.			T, corr. time.	Right ascension.			Δ T
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
G.	Gr. 750, L. C.										3	59	07.24	
A.	ζ Ophiuchi	D.	−0.21	−0.05	−0.07	0.00	16	30	24.69	24.36	16	30	33.66	9.30
G.	ζ Herculis	D.	−0.06	−0.09	−0.09			36	37.82	37.58		36	46.78	9.20
A.	η Herculis	D.	−0.02	−0.10	−0.09			38	39.09	38.88		38	48.09	9.21
G.	49 Herculis	D.	−0.12	−0.07	−0.08			46	28.87	28.60		46	37.82	9.23
A.	κ Ophiuchi	D.	−0.14	−0.06	−0.07			51	51.03	50.76		51	59.98	9.22
G.	ε Herculis	D.	−0.06	−0.08	−0.08			55	33.95	33.73		55	42.94	9.21
A.	α¹ Herculis	R.	−0.13	−0.06	+0.04		17	09	02.32	02.17	17	09	11.36	9.19
G.	π Herculis	R.	−0.03	−0.08	+0.05			10	44.24	44.18		10	53.27	9.09
A.	α Ophiuchi	R.	−0.13	−0.07	+0.04			29	13.67	13.51		29	22.67	9.16
G.	β Ophiuchi	R.	−0.16	−0.07	+0.04			37	24.49	24.30		37	33.45	9.15
G.	γ Ophiuchi	R.	−0.17	−0.07	+0.04			41	44.36	44.16		41	53.31	9.15
G.	θ Herculis	R.	−0.03	−0.12	+0.05			52	00.51	00.41		52	09.53	9.12
G.	67 Ophiuchi	R.	−0.17	−0.07	+0.04			54	29.95	29.75		54	38.95	9.20
G.	72 Ophiuchi	R.	0.14	−0.09	+0.04	0.00	18	01	31.50	31.31	18	01	40.48	9.17
A.	δ Urs. Min										18	11	27.43	
A.	λ Urs. Min										19	45	26.87	
A	α²Capricorni	R.	−0.22	−0.05	+0.04	0.00	20	11	15.63	15.40	20	11	24.52	9.12
G.	γ Cygni	R.	−0.02	−0.14	+0.05			17	47.36	47.25		17	56.52	9.27
A.	π Capricorni	R.	−0.24	−0.06	+0.04			20	19.03	18.77		20	27.91	9.14
A.	γ² Delphini	R.	−0.14	−0.10	+0.04	0.00	20	27	20.56	20.36		27	29.55	9.19
G.	ε Delphini	R.	−0.12	−0.11	+0.04	0.00	20	33	55.64	55.45	20	34	04.63	9.18
G.	α Delphini	D.	−0.12	−0.06	−0.08			40	57.25	56.99		41	06.23	9.24
A.	μ Aquarii	D.	−0.21	−0.04	−0.07			46	02.68	02.36		46	11.51	9.15
A.	ν Cygni	D.	−0.01	−0.10	0.10			52	34.09	33.88		52	43.04	9.16
A.	61¹ Cygni	D.	−0.02	−0.10	−0.09		21	01	22.99	22.78	21	01	31.99	9.21
A.	ζ Cygni	D.	−0.07	−0.10	−0.08	0.00		07	41.54	41.29		07	50.55	9.26
A.	1 Draconis L. C.										9	19	43.37	

$\theta + \delta\theta = +9^{s}.188$ = clock-error at 19^{h} clock-time.
ρ = hourly rate = $-0^{s}.001$ (gaining).

NORMAL EQUATIONS.

$$-\ 8.41\ \delta\theta - 3.84\,a + 75.86\,\rho + 1.48 = 0$$
$$+10.78\ \delta\theta + 12.55\,a - 8.84\,\rho + 0.19 = 0$$
$$+24.069\,\delta\theta - 10.78\,a - 8.41\,\rho - 4.10 = 0$$

$$\delta\theta = +0^{s}.288 \qquad a = -0^{s}.262 \qquad \rho = -0^{s}.001$$

TABLE 5.—*Detroit time, July 26, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δi + ab)	R ρ	T′, obsd. time.	T, corr. time.	Right ascension.	ΔT
			s.	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*h. m. s.*	*s.*
A.	δ Urs. Min								18 11 23.76	
A.	1 Aquilæ	R.	− 0.34	− 0.03	+ 0.02	+ 0.02	18 28 34.33	34.00	28 41.45	+7.45
A.	α Lyræ	R.	− 0.03	− 0.04	+ 0.02	+ 0.01	32 46.28	46.24	32 53.85	7.61
G.	110 Herculis	R.	− 0.17	− 0.01	+ 0.02	+ 0.01	40 23.58	23.43	40 30.88	7.45
A.	β Lyræ	R.	− 0.08	+ 0.02	+ 0.02	+ 0.01	45 32.80	32.77	45 40.20	7.43
G.	θ Serpentis	R.	− 0.27	+ 0.02	+ 0.02	+ 0.01	50 08.98	08.76	50 16.17	7.41
G.	ε Aquilæ	R.	− 0.21	+ 0.04	+ 0.02	+ 0.01	54 04.25	04.11	54 11.60	7.49
A.	ζ Aquilæ	D.	− 0.21	+ 0.00	− 0.05	+ 0.01	59 47.48	47.23	59 54.60	7.37
G.	ι Lyræ	D.	− 0.06	+ 0.01	− 0.06	+ 0.01	19 02 55.16	55.06	19 03 02.52	7.46
G.	ω Aquilæ	D.	− 0.23	+ 0.01	− 0.05	+ 0.01	12 04.84	04.58	12 12.04	7.46
A.	δ Aquilæ	D.	− 0.28	+ 0.02	− 0.05	+ 0.01	19 20.65	20.35	19 27.79	7.44
G.	β Cygni	D.	− 0.12	+ 0.03	− 0.05	+ 0.01	25 46.75	46.62	25 54.10	7.48
A.	κ Aquilæ	D.	− 0.33	+ 0.02	+ 2.62	+ 0.01	19 30 17.40	19.72	30 27.08	7.36
A.	λ Urs. Min								45 23.24	
A.	ξ Aquarii	R.	− 0.34	− 0.06	+ 0.02	− 0.01	21 31 15.61	15.22	21 31 22.71	7.49
A.	ε Pegasi	R.	− 0.24	− 0.06	+ 0.02	− 0.01	38 11.22	10.93	38 18.47	7.54
A.	μ Capricorni	R.	− 0.37	− 0.02	+ 0.02	− 0.01	46 39.05	38.67	46 46.13	7.46
G.	20 Pegasi	R.	− 0.22	− 0.05	+ 0.02	− 0.01	55 08.24	07.98	55 15.46	7.48
A.	α Aquarii	R.	− 0.29	− 0.05	+ 0.02	− 0.01	59 30.92	30.59	59 38.07	7.48
G.	θ Pegasi	R.	− 0.26	− 0.07	+ 0.02	− 0.01	22 04 02.48	02.16	22 04 09.61	7.45
A.	θ Aquarii	R.	− 0.34	− 0.07	+ 0.02	− 0.01	10 23.90	23.50	10 30.90	7.40
G.	γ Aquarii	D.	− 0.30	− 0.04	− 0.05	− 0.01	22 15 21.29	20.89	22 15 28.27	7.38
A.	π Aquarii	D.	− 0.29	− 0.04	− 0.05	− 0.01	19 02.65	02.26	19 09.70	7.44
A.	η Aquarii	D.	− 0.29	− 0.04	− 0.05	− 0.02	29 05.07	04.67	29 12.13	7.46
A.	ζ Pegasi	D.	− 0.23	− 0.05	− 0.05	− 0.02	35 22.26	21.91	35 29.29	7.38
G.	λ Pegasi	D.	− 0.16	− 0.06	− 0.05	− 0.02	40 38.61	38.32	40 45.84	7.52
G.	μ Pegasi	D.	− 0.15	− 0.06	− 0.05	− 0.02	44 06.18	05.90	44 13.41	+7.51
G. B.	Carr. 3525								22 55 25.01	

$\theta + \delta\theta = +\ 7^s.455$ = clock-error at $20^h.5$ clock-time.
ρ = hourly rate = $-0^s.0076$ (gaining).

NORMAL EQUATIONS.

$$+\ 3.86\,\delta\theta + 4.81\,a + 67.12\,\rho + 1.06 = 0$$
$$+\ 13.18\,\delta\theta + 11.75\,a + 4.81\,\rho - 0.89 = 0$$
$$+\ 25.03\,\delta\theta + 13.18\,a + 3.86\,\rho - 5.68 = 0$$

$$\delta\theta = +\ \overset{s.}{0.455} \qquad a = -\ \overset{s.}{0.432} \qquad \rho = -\ \overset{s.}{0.0076}$$

TABLE 6.—*Detroit time, July 28, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C $(c+\Delta i+ab)$	R ρ	T', obsd. time.			T, corr. time.	Right ascension.			Δ T
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
A.	δ Urs. Min										18	11	23.20	
A.	1 Aquilæ	R.	− 0.37	+ 0.01	+ 0.01	+ 0.03	18	28	34.56	34.24		28	41.45	+ 7.21
A.	α Lyræ	R.	− 0.04	+ 0.02	+ 0.01	+ 0.03		32	46.47	46.49		32	53.84	7.35
G.	110 Herculis	R.	− 0.19	+ 0.02	+ 0.01	+ 0.03		40	23.81	23.68		40	30.87	7.19
A.	β Lyræ	R.	− 0.09	+ 0.04	+ 0.01	+ 0.03		45	32.97	32.96		45	40.19	7.23
G.	θ' Serpentis	R.	− 0.30	+ 0.03	+ 0.01	+ 0.03		50	09.18	08.95		50	16.17	7.22
G.	ε Aquilæ	R.	− 0.23	+ 0.04	+ 0.01	+ 0.03		54	04.52	04.37		54	11.60	7.23
A.	ζ Aquilæ	D.	− 0.23	+ 0.04	− 0.04	+ 0.03		59	47.70	47.50		59	54.60	7.10
G.	ι Lyræ	D.	− 0.07	+ 0.05	− 0.05	+ 0.03	19	02	55.39	55.35	19	03	02.51	7.16
A.	δ Aquilæ	D.	− 0.31	+ 0.03	− 0.04	+ 0.02		19	21.00	20.70		19	27.80	7.10
G.	β Cygni	D.	− 0.13	+ 0.04	− 0.04	+ 0.02		25	47.07	46.96		25	54.10	7.14
A.	κ Aquilæ	D.	− 0.37	+ 0.02	− 0.04	+ 0.02		30	20.32	19.95		30	27.09	7.14
A.	λ Urs. Min											45	22.39	
G.	γ Piscium	R.	− 0.16	+ 0.05	+ 0.01	− 0.02	23	10	50.31	50.19	23	10	57.28	7.09
G. B.	Carr. 3621											28	01.15	
G.	φ Pegasi	D.	− 0.11	+ 0.04	− 0.04	− 0.02		46	16.43	16.30		46	23.50	7.20
A.	ω Piscium	D.	− 0.15	+ 0.03	− 0.04	− 0.02		53	02.38	02.20		53	09.44	7.24
A.	α Andromedæ	D.	− 0.07	+ 0.05	− 4.82	− 0.03	0	02	09.10	04.23	0	02	11.58	7.35
A.	γ Pegasi	D.	− 0.12	+ 0.04	− 1.08	− 0.03		06	57.70	56.51		07	03.82	7.31
G.	12 Ceti	R.	− 0.18	+ 0.03	+ 0.01	− 0.03		23	48.21	48.04		23	55.22	7.18
G.	π Andromedæ	R.	− 0.05	+ 0.05	+ 0.01	− 0.03		30	21.54	21.52		30	28.65	7.13
G.	δ Andromedæ	R.	− 0.06	+ 0.05	+ 0.01	− 0.03	0	32	47.80	47.77	0	32	55.02	7.25
A.	β Ceti	R.	− 0.23	+ 0.02	+ 0.01	− 0.03		37	27.40	27.17		37	34.24	7.07
G.	δ Piscium	R.	− 0.15	+ 0.03	+ 0.01	− 0.03		42	20.61	20.47		42	27.61	7.14
A.	α Urs. Min										1	14	49.14	

$\theta+\delta\theta=+\ 7^s.192$ = clock-error at $21^h.5$ clock-time.
ρ = hourly rate $= -0^s.0106$ (gaining).

NORMAL EQUATIONS.

$$\begin{aligned}
-\ 1.39\ \delta\theta - 11.87\,a + 13.27\,a' + 145.83\,\rho - 0.23 &= 0\\
+\ 4.94\ \delta\theta + 0.00\,a + 4.83\,a' + 13.27\,\rho - 0.63 &= 0\\
+\ 4.74\ \delta\theta + 5.44\,a + 0.00\,a' - 11.87\,\rho + 0.57 &= 0\\
+20.969\ \delta\theta + 4.74\,a + 4.94\,a' - 1.39\,\rho - 4.94 &= 0
\end{aligned}$$

$\delta\theta = +\overset{s.}{0}.402$ $\quad a = -\overset{s.}{0}.479$ before signals. $\quad a' = -\overset{s.}{0}.252$ after signals. $\quad \rho = -\overset{s.}{0}.0106$.

TABLE 7.—*Detroit time, July 29, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δi + ab)	R ρ	T', obsd. time.			T, corr. time.	Right ascension.			Δ T
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
A.	δ Urs. Min										18	11	22.90	
A.	1 Aquilæ	R.	− 0.26	+ 0.02	− 0.04	0.00	18	28	34.62	34.34		28	41.45	+ 7.11
A.	α Lyræ	R.	− 0.03	+ 0.06	− 0.05			32	46.65	46.63		32	53.83	7.20
G.	110 Herculis	R.	− 0.13	+ 0.06	− 0.04			40	23.91	23.80		40	30.87	7.07
A.	β Lyræ	R.	− 0.06	+ 0.09	− 0.05			45	33.10	33.08		45	40.18	7.10
G.	θ' Serpentis	R.	− 0.21	+ 0.07	− 0.04			50	09.40	09.22		50	16.17	6.95
G.	ε Aquilæ	R.	− 0.16	+ 0.08	− 0.04			54	04.62	04.50		54	11.60	7.10
A.	ζ Aquilæ	D.	− 0.16	+ 0.08	+ 0.01			59	47.66	47.59		59	54.60	7.01
G.	ι Lyræ	D.	− 0.05	+ 0.10	+ 0.01		19	02	55.25	55.31	19	03	02.50	7.19
G.	ω Aquilæ	D.	− 0.18	+ 0.07	+ 0.01			12	05.08	04.98		12	12.04	7.06
A.	δ Aquilæ	D.	− 0.21	+ 0.06	+ 0.01			19	20.97	20.83		19	27.80	6.97
G.	β Cygni	D.	− 0.09	+ 0.08	+ 0.01			25	47.91	47.01		25	54.10	7.09
A.	κ Aquilæ	D.	− 0.26	+ 0.05	+ 0.01	0.00		30	20.29	20.09		30	27.09	7.00
A.	λ Urs. Min											45	21.86	
A.	1 Draconis L. C										9	19	42.91	
A.	ξ Aquilæ	D.	− 0.26	+ 0.01	+ 0.01	0.00	21	31	15.86	15.62	21	31	22.76	7.14
A.	μ Capricorni	D.	− 0.29	+ 0.02	+ 0.01			46	39.29	39.03		46	46.18	7.15
G.	20 Pegasi	D.	− 0.17	+ 0.04	+ 0.01			55	08.56	08.44		55	15.51	7.07
A.	α Aquarii	D.	− 0.23	+ 0.03	+ 0.01			59	31.18	30.99		59	38.12	7.13
G.	θ Pegasi	D.	− 0.20	+ 0.04	+ 0.01		22	04	02.73	02.58	22	04	09.66	7.08
A.	θ Aquarii	D.	− 0.26	+ 0.04	+ 0.01	0.00		10	24.04	23.83		10	30.96	7.13
A.	π Aquarii	R.	− 0.22	+ 0.05	− 0.04	0.00	22	19	03.02	02.81	22	19	09.76	6.95
A.	η Aquarii	R.	− 0.23	+ 0.05	− 0.04			29	05.45	05.23		29	12.19	6.96
A.	ζ Pegasi	R.	− 0.18	+ 0.05	− 0.04			35	22.60	22.43		35	29.35	6.92
G.	λ Pegasi	R.	− 0.12	+ 0.06	− 0.05			40	38.84	38.73		40	45.90	7.17
G.	μ Pegasi	R.	− 0.11	+ 0.06	− 0.05			44	06.35	06.25		44	13.47	7.22
A.	λ Aquarii	R.	− 0.26	+ 0.03	− 0.04	0.00		46	15.19	14.92		46	21.95	+ 7.03
G. B.	Carr. 3525										22	55	25.34	

$\theta + \delta\theta = + 7^s.075 =$ clock-error at $20^h.5$ clock-time.
$=$ hourly rate $= - 0^s.002$ (gaining).

NORMAL EQUATIONS.

$$+ 2.78\ \delta\theta + 4.89 a + 67.95 \rho + 0.73 = 0$$
$$+ 12.90\ \delta\theta + 12.66 a + 4.89 \rho - 0.61 = 0$$
$$+ 24.062\ \delta\theta + 12.90 a + 2.78 \rho - 0.72 = 0$$

$$\delta\theta = + 0^s.375 \qquad a = - 0^s.333 \qquad \rho = - 0^s.002.$$

TABLE 8.—*Detroit time, July 30, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δi + ab)	R ρ	T′, obsd. time.			T, corr. time.	Right ascension.			Δ T
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
A.	δ Urs. Min										18	11	22.58	
A.	1 Aquilæ	R.	− 0.51	− 0.03	+ 0.05	+ 0.03	18	28	34.98	34.52		28	41.45	+ 6.93
A.	α Lyræ	R.	− 0.05	− 0.06	+ 0.06	+ 0.03		32	46.65	46.63		32	53.83	7.20
G.	110 Herculis	R.	− 0.26	− 0.03	+ 0.05	+ 0.03		40	24.04	23.83		40	30.87	7.04
A.	β Lyræ	R.	− 0.12	− 0.02	+ 0.06	+ 0.03		45	33.31	33.26		45	40.18	6.92
G.	θ′ Serpentis	R.	− 0.40	− 0.00	+ 0.05	+ 0.03		50	09.54	09.22		50	16.17	6.95
A.	ζ Aquilæ	D.	− 0.32	0.00	− 0.08	+ 0.03		59	47.98	47.61		59	54.60	6.99
G.	ι Lyræ	D.	− 0.09	0.00	− 0.10	+ 0.03	19	02	55.77	55.61	19	03	02.50	6.89
G.	ω Aquilæ	D.	− 0.34	0.00	− 0.08	+ 0.02		12	05.39	05.00		12	12.04	7.04
A.	δ Aquilæ	D.	− 0.42	0.00	− 0.08	+ 0.02		19	21.34	20.86		19	27.81	6.95
G.	β Cygni	D.	− 0.18	0.00	− 0.09	+ 0.02		25	47.51	47.26		25	54.10	6.84
A.	κ Aquilæ	D.	− 0.50	0.00	− 0.08	+ 0.02		30	20.74	20.18		30	27.10	6.92
A.	λ Urs. Min											45	21.27	
G B.	Carr. 3525										22	55	25.45	
G.	τ Pegasi	D.	− 0.15	+ 0.04	− 0.09	− 0.02	23	14	35.87	35.65	23	14	42.58	6.93
G.	υ Pegasi	D.	− 0.15	+ 0.04	− 0.09	− 0.02		19	17.43	17.21		19	24.07	6.86
A.	θ Piscium	D.	− 0.25	+ 0.03	− 0.08	− 0.02		21	46.98	46.66		21	53.48	6.82
G.	72 Pegasi	D.	− 0.10	+ 0.05	− 0.09	− 0.02		27	54.06	53.90		28	00.70	6.80
G.	ι Andromedæ	D.	− 0.00	+ 0.06	− 0.11	− 0.02		32	08.91	08.84		32	15.95	7.11
A.	Piscium	D.	− 0.26	+ 0.03	− 0.08	− 0.02		33	40.76	40.43		33	47.34	6.91
G.	φ Pegasi	R.	− 0.18	+ 0.05	− 0.05	− 0.02		46	16.64	16.54		46	23.55	7.01
A.	ω Piscium	R.	− 0.25	+ 0.04	+ 0.05	− 0.03	23	53	02.70	02.51	23	53	09.49	6.98
A.	α Andromedæ	R.	− 0.12	+ 0.03	+ 0.06	− 0.03	0	02	04.52	04.46	0	02	11.64	7.18
A.	γ Pegasi	R.	− 0.20	+ 0.02	+ 0.05	− 0.03		06	56.96	56.80		07	03.87	7.07
G.	ι Ceti	R.	− 0.34	+ 0.00	+ 0.05	− 0.03		13	12.63	12.31		13	19.28	6.97
G.	12 Ceti	R.	− 0.31	− 0.01	+ 0.05	− 0.03		23	48.60	48.30		23	55.27	+ 6.97
A.	32² Camelopardalis L. C										12	48	12.85	

$\theta + \delta\theta = +\ 0^s.971$ = clock-error at $21^h.5$ clock-time.

ρ = hourly rate = $-\ 0^s.0105$ (gaining).

NORMAL EQUATIONS.

$$-\ 0.680\,\delta\theta - 11.84\,a + 13.28\,a' + 133.43\,\rho - 0.320 = 0$$
$$+\ 5.55\,\delta\theta + 0.00\,a + 5.46\,a' + 13.28\,\rho - 0.730 = 0$$
$$+\ 4.79\,\delta\theta + 5.49\,a + 0.00\,a' - 11.84\,\rho + 0.710 = 0$$
$$+\ 28.057\,\delta\theta + 4.79\,a + 5.55\,a' - 0.68\,\rho - 7.710 = 0$$

$= +$ [illegible] $\quad a = -\ 0^s.65 \quad a' = -$ [illegible] $\quad \rho = -\ 0^s.0105$

TABLE 9.—*Detroit time, August 26, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δ i + ab)	R ρ	T', obsd. time.			T, corr. time.	Right ascension.			Δ T
			s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.
A.	δ Urs. Min										18	11	13.53	+ 5.85
A.	1 Aquilæ	R.	− 0.03	− 0.03	− 0.14	− 0.03	18	28	35.63	35.40		28	41.25	5.85
A.	α Lyræ	R.	− 0.00	− 0.05	− 0.17	− 0.03		32	47.70	47.45		32	53.44	5.99
G.	110 Herculis	R.	− 0.01	− 0.02	− 0.14	− 0.03		40	24.92	24.72		40	30.64	5.92
A.	β Lyræ	R.	− 0.01	− 0.01	− 0.16	− 0.03		45	34.11	33.90		45	39.87	5.97
G.	ε Aquilæ	R.	− 0.02	+ 0.01	− 0.14	− 0.02		54	05.67	05.50		54	11.42	5.92
A.	ζ Aquilæ	D.	− 0.02	− 0.01	+ 0.11	− 0.02		59	48.58	48.64		59	54.42	5.78
G.	ι Lyræ	D.	− 0.00	− 0.01	+ 8.37	− 0.02	19	02	47.91	56.25	19	03	02.24	5.99
G.	ω Aquilæ	D.	− 0.02	− 0.02	+ 0.11	− 0.02		12	06.00	06.05		12	11.92	5.87
A.	δ Aquilæ	D.	− 0.02	− 0.02	+ 0.10	− 0.02		19	21.79	21.83		19	27.70	5.87
G.	β Cygni	D.	− 0.01	− 0.04	+ 0.12	− 0.02		25	47.97	48.02		25	53.94	5.92
A.	κ Aquilæ	D.	− 0.02	− 0.03	+ 0.11	− 0.02		30	21.21	21.25		30	27.04	5.79
A.	λ Urs. Min											45	02.08	
A.	1 Draconis, L. C										9	19	43.89	
A.	ξ Aquarii	D.	− 0.02	− 0.05	+ 0.11	+ 0.02	21	31	16.93	16.99	21	31	23.00	6.01
A.	ε Pegasi	D.	− 0.02	− 0.07	+ 0.11	+ 0.02		38	12.67	12.71		38	18.76	6.05
A.	μ Capricorni	D.	− 0.03	− 0.05	+ 0.11	+ 0.02		46	40.39	40.44		46	46.48	6.04
G.	20 Pegasi	D.	− 0.02	− 0.08	+ 0.11	+ 0.02		55	09.78	09.81		55	15.81	6.00
A.	α Aquarii	D.	− 0.02	− 0.06	+ 0.10	+ 0.02		59	32.38	32.42		59	38.42	6.00
G.	θ Pegasi	D.	− 0.02	− 0.07	+ 0.11	+ 0.02	22	04	03.94	03.98	22	04	09.99	6.01
A.	θ Aquarii	D.	− 0.02	− 0.06	+ 0.11	+ 0.02		10	25.30	25.35		10	31.31	5.96
G.	γ Aquarii	R.	− 0.02	− 0.05	− 0.14	+ 0.03		15	22.98	22.80		15	28.69	5.89
A.	π Aquarii	R.	− 0.02	− 0.05	− 0.14	+ 0.03	22	19	04.50	04.32	22	19	10.11	5.79
A.	η Aquarii	R.	− 0.02	− 0.06	− 0.14	+ 0.03		29	06.90	06.71		29	12.57	5.86
A.	ζ Pegasi	R.	− 0.02	− 0.07	− 0.14	+ 0.03		35	24.11	23.91		35	29.75	5.84
G.	λ Pegasi	R.	− 0.01	− 0.09	− 0.15	+ 0.03		40	40.66	40.44		40	46.34	5.90
G.	μ Pegasi	R.	− 0.01	− 0.09	− 0.15	+ 0.03		44	08.22	08.00		44	13.91	5.91
A.	λ Aquarii	R.	− 0.02	− 0.06	− 0.14	+ 0.03	22	46	16.80	16.61		46	22.39	+ 5.78
G. B.	Carr. 3525										22	55	27.19	

$\theta + \delta\theta = +5^s.912$ = clock-error at $20^h.5$ clock-time.
ρ = hourly rate = $+0^s.015$ (losing).

NORMAL EQUATIONS.

$$+7.33\ \delta\theta + 7.77\ a + 69.50\ \rho - 2.34 = 0$$
$$+13.53\ \delta\theta + 13.12\ a + 7.77\ \rho - 2.56 = 0$$
$$+25.053\ \delta\theta + 13.53\ a + 7.33\ \rho - 4.96 = 0$$

$$\delta\theta = +0^s.212 \qquad a = -0^s.092 \qquad \rho = +0^s.015$$

TABLE 10.—*Detroit time, August 27, 1879.—Capt. D. W. Lockwood, observer.*

Authority.	Star.	Telescope.	A a	B b	C (c + Δi + ab)	R ρ	T′, obsd. time.	T, corr. time.	Right ascension.	Δ T
			s.	s.	s.	s.	h. m. s.	s.	h. m. s.	s.
A.	δ Urs. Min								18 11 13.10	
A.	1 Aquilæ	R.	— 0.23	— 0.04	— 0.14	— 0.02	18 28 35.48	35.05	28 41.24	+ 6.19
A.	α Lyræ	R.	— 0.02	— 0.06	— 0.17	— 0.02	32 47.45	47.18	32 53.42	6.24
G.	110 Herculis	R.	— 0.12	— 0.03	— 0.14	— 0.02	40 24.74	24.43	40 30.63	6.20
A.	β Lyræ	R.	— 0.06	— 0.03	— 0.16	— 0.02	45 33.98	33.71	45 39.85	6.14
G.	θ′ Serpentis	R.	— 0.18	— 0.01	— 0.14	— 0.02	50 10.19	09.84	50 16.01	6.17
G.	ε Aquilæ	R.	— 0.14	— 0.00	— 8.93	— 0.02	54 14.37	05.28	54 11.41	6.13
A.	ζ Aquilæ	D.	— 0.14	— 0.00	+ 0.11	— 0.01	59 48.36	48.32	59 54.41	6.09
G.	ι Lyræ	D.	— 0.04	— 0.00	+ 0.13	— 0.01	19 02 56.03	56.11	19 03 02.22	6.11
G.	ω Aquilæ	D.	— 0.15	— 0.00	+ 0.11	— 0.01	12 05.77	05.72	12 11.91	6.19
A.	δ Aquilæ	D.	— 0.19	— 0.00	+ 0.10	— 0.01	19 21.62	21.52	19 27.69	6.17
G.	β Cygni	D.	— 0.08	— 0.01	+ 0.12	— 0.01	25 47.75	47.77	25 53.93	6.16
A.	κ Aquilæ	D.	— 0.22	0.00	+ 0.11	— 0.01	30 21.01	20.89	30 27.03	6.14
A.	λ Urs. Min								45 01.01	
A.	1 Draconis, L. C								9 19 43.95	
A.	ξ Aquarii	D.	— 0.23	— 0.00	+ 0.11	+ 0.01	21 31 16.97	16.86	21 31 23.00	6.14
A.	ε Pegasi	D.	— 0.16	+ 0.00	+ 0.11	+ 0.01	38 12.56	12.52	38 18.76	6.24
A.	μ Capricorni	D.	— 0.25	+ 0.01	+ 0.11	+ 0.01	46 40.44	40.32	46 46.48	6.16
G.	20 Pegasi	D.	— 0.15	+ 0.03	+ 0.11	+ 0.01	55 09.62	09.62	55 15.82	6.20
A.	α Aquarii	D.	— 0.20	+ 0.03	+ 0.10	+ 0.01	59 32.35	32.29	59 38.43	6.14
G.	θ Pegasi	D.	— 0.17	+ 0.04	+ 0.11	+ 0.02	22 04 03.80	03.80	22 04 10.00	6.20
A.	θ Aquarii	D.	— 0.23	+ 0.04	+ 0.11	+ 0.02	10 25.26	25.20	10 31.32	6.12
G.	γ Aquarii	R.	— 0.20	+ 0.03	— 0.14	+ 0.02	22 15 22.80	22.51	22 15 28.70	6.19
A.	π Aquarii	R.	— 0.19	+ 0.03	— 0.14	+ 0.02	19 04.20	03.92	19 10.12	6.20
A.	η Aquarii	R.	— 0.20	+ 0.04	— 0.14	+ 0.02	29 06.70	06.42	29 12.58	6.16
A.	ζ Pegasi	R.	— 0.16	+ 0.04	— 0.14	+ 0.02	35 23.85	23.61	35 29.76	6.15
G.	λ Pegasi	R.	— 0.10	+ 0.05	— 0.15	+ 0.02	40 40.35	40.17	40 46.35	6.18
G.	μ Pegasi	R.	— 0.10	+ 0.06	— 0.15	+ 0.02	44 07.90	07.73	44 13.92	6.19
A.	λ Aquarii	R.	— 0.23	+ 0.04	— 8.75	+ 0.02	46 25.26	16.34	46 22.40	+ 6.06
G. B.	ι Carr. 3525								22 55 27.21	

$\theta + \delta\theta = +6^s.164$ = clock-error at $20^h.5$ clock-time.
ρ = hourly rate = $+0^s.0097$ (losing).

$$+5.66\ \delta\theta + 6.73\,a + 72.29\,\rho - 0.81 = 0$$
$$+14.15\ \delta\theta + 13.50\,a + 6.73\,\rho - 1.30 = 0$$
$$+26.063\ \delta\theta + 14.15\,a + 5.66\,\rho - 5.44 = 0$$

$\delta\theta = +0^s.364 \qquad a = -0^s.29 \qquad \rho = +0^s.0097$

2. REPORT ON OBSERVATIONS FOR LONGITUDE OF OLNEY, ILL., AND LATITUDE OF STATION PARKERSBURG, BY LIEUT. P. M. PRICE, CORPS OF ENGINEERS.

DETROIT, MICH., *May 27*, 1880.

SIR: I have the honor to submit herewith the tabulated results of the astronomical observations made by me for the longitude of Olney, Ill. The work was done during the summer of 1879, by Captain Lockwood and myself.

A description of the methods of observation and reduction will be found in the report of Captain Lockwood. We each reduced our own observations in the first place, and then duplicated the computations of the other. The adopted results for the longitude of Olney, Ill., and for our personal equation are given in Captain Lockwood's report.

The astronomical post at Olney, Ill., is a roughly dressed limestone block 4 feet by 17 inches by 18 inches, sunk 3 feet in the ground. On top of this, and firmly bolted to it by two iron bolts, is placed a smoothly dressed block, 12 by 20 by 25 inches. On the top of the upper stone, the letters U. S. are cut. The position occupied by the center of the instrument during the observations is marked by a hole ½ inch in diameter. A meridian mark, a stone 4 feet by 8 inches by 4 inches, with a groove cut in top to mark the meridian is set at a distance of 65 meters to the north of the observing-post, a longer distance being impracticable. The astronomical post is in the yard of the public school at Olney. Connections with permanent points are given in the note-book of observations. The instruments used were Würdemann astronomical transit No. 1, focal length 31 inches, 2½ inches object-glass; Negus break-circuit sidereal chronometer No. 1524; and Bond & Son's chronograph No. 245.

The time-results are given in the appended tables, numbered from 1 to 8, inclusively. In these tables—

A = the azimuth factor.
B = the inclination factor.
C = the collimation factor.
a = the assumed value for azimuth of transit instrument.
δa = the correction to a determined from normal equations.
b = the level correction.
c = the correction for collimation.
Δi = the reduction to the middle wire.
abr = the correction for diurnal aberration = $-0^s.021$ cos. latitude.
R = the interval in chronometer hours for which the rate ρ is applied.
ρ = the rate per chronometer hour, + when losing, — minus when gaining.
p = the weight given to the chronometer correction as determined from a single star.
θ = the assumed value for chronometer correction at a given epoch.
$\delta\theta$ = the correction to θ determined from normal equations.
Δt_0 = the chronometer correction at a given epoch = $(\theta + \delta\theta)$, + when slow, — when fast.

The right ascensions were determined from the American Ephemeris, 1879; German Catalogue of 539 stars, 1879; and General Bericht Europäische Gradmessung, 1873.

LATITUDE OF STATION PARKERSBURG.

After completing the observations at Olney, I went to Parkersburg primary triangulation station, the last station of the triangulation extending south from Chicago, for the purpose of determining its latitude. The observing-pier was a heavy wooden post sunk 3 feet in the ground, 87° 43′ west of north and 34.68 meters distant from the geodetic point. The observations were made with Würdemann zenith telescope No. 19. The telescope has a focal length of 32 inches and an aperture of 3 inches. The value of one revolution of its micrometer-screw is 62″.224 and of one division of its level is 1″.292.

Observations were made on five nights. The individual results, the arithmetical and weighted means and the final result for the latitude of Station Parkersburg are given in Table 9. The weight p to be given to the latitude resulting from a night's observations on one pair of stars is deduced from the formula, $p = \frac{n}{nE_\delta^2 + E_0^2}$ given in Appendix 2 of the Lake Survey Report for 1873. E_δ is the probable error in the half sum of the declinations of one pair of stars and E_0 is the probable error in the half difference of zenith distances of one pair resulting from one measurement of it. The values for E_δ and E_0 taken from office report No. 386, were $E_\delta = 0''.57$ and $E = 0''.42$.

The declinations were taken from Safford's Catalogue of 2,018 stars, Washington, Government Printing Office, 1879, except for two stars not in that catalogue which

were taken from the United States Coast Survey Catalogue in Appendix 7, of the Report for 1876.

The constants for computing apparent declinations were taken from the American Ephemeris for 1879.

The reductions of the latitude work were made in duplicate by Assistant Engineers J. H. Darling and B. D. King.

Very respectfully, your obedient servant,

PHILIP M. PRICE,
First Lieutenant of Engineers.

Maj. C. B. COMSTOCK,
Corps of Engineers.

TABLE 1.—*Detroit, July 5, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a+\delta a)$	B b	C $(c+\Delta i+abr)$	R ρ	Observed time.			Corrected time.	Right ascension.			Chronometer correction.		No. of wires.	p.
		s.		*s.*	*s.*	*h.*	*m.*	*s.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*		
	Carr. 580, L. C	....		....	....	....			....	4	00	19.91	....		17	0.041
E.	ϵ Herculis	+ 0.23	+ 0.06	− 0.57	+ 0.21	16	57	50.38	50.31	16	55	42.95	− 2	07.36	11	1.
W.	a^1 Herculis	+ 0.49	+ 0.04	+ 0.47	+ 0.19	17	11	17.52	18.71	17	09	11.36	− 2	07.35	11	1.
W.	π Herculis	+ 0.12	+ 0.07	+ 0.57	+ 0.19		12	59.68	60.63		10	53.28	− 2	07.35	11	1.
W.	α Ophiuchi	+ 0.51	+ 0.06	+ 0.47	+ 0.16		31	28.80	30.00		29	22.67	− 2	07.33	11	1.
W.	β Ophiuchi	+ 0.63	+ 0.05	+ 0.46	+ 0.14		39	39.50	40.78		37	33.44	− 2	07.34	11	1.
W.	γ Ophiuchi	+ 0.65	+ 0.05	+ 0.46	+ 0.13		43	59.39	60.68		41	53.30	− 2	07.38	11	1.
E.	θ Herculis	+ 0.11	+ 0.03	− 0.62	+ 0.12		54	17.24	16.88		52	09.54	− 2	07.34	11	1.
E.	67 Ophiuchi	+ 0.65	+ 0.01	− 0.49	+ 0.11		56	45.91	46.19		54	38.94	− 2	07.25	11	1.
E.	72 Ophiuchi	0.56	0.02	0.50	+ 0.10	18	03	47.58	47.72	18	01	40.47	− 2	07.25	11	1.
	δ Urs. Min	....	....	....	....	....			....		11	27.85	....		11	0.019
	λ Urs. Min	....	....	....	....	....			....	19	45	26.99	....		11	0.001
E.	α^2 Capricorni	+ 0.86	− 0.03	0.50	− 0.13	20	13	31.54	31.74	20	11	24.47	2	07.27	11	1.
E.	γ Cygni	+ 0.06	− 0.04	0.06	− 0.14		20	04.03	03.85		17	56.48	− 2	07.37	11	1.
E.	π Capricorni	+ 0.94	+ 0.01	0.52	− 0.15		22	34.97	35.25		20	27.85	2	07.40	11	1.
E.	ϵ Delphini	+ 0.54	0.00	0.50	0.16		29	37.02	36.90		27	29.50	− 2	07.40	11	1.
E.	α Delphini	+ 0.48	0.00	0.51	0.17		36	12.10	11.90		34	04.58	2	07.32	11	1.
W.	ν^2 Delphini	+ 0.48	0.00	+ 0.45	0.18		43	12.70	13.45		41	06.18	2	07.27	11	1.
W.	μ Aquarii	+ 0.81	0.00	+ 0.46	− 0.19		48	17.87	18.95		46	11.45	− 2	07.50	11	1.
W.	ν Cygni	+ 0.04	+ 0.04	+ 0.61	− 0.20		54	49.81	50.30		52	42.98	− 2	07.32	11	1.
W.	61[1] Cygni	+ 0.09	+ 0.05	+ 0.58	− 0.22	21	03	38.65	39.15	21	01	31.93	− 2	07.22	11	1.
W.	ζ Cygni	+ 0.26	+ 0.05	+ 0.26	− 0.23		09	57.41	57.75		07	50.49	− 2	07.26	11	1.
	1 Draconis, L. C	....	....	....	....	....			....	9	19	43.51	....		16	0.1.24

	s.
From Carr. 580,	C = + 0.502 clamp W.
δ Urs. Min.,	C = + 0.468 clamp W.
λ Urs. Min.,	C = + 0.512 clamp W.
1 Draconis,	C = + 0.517 clamp W.
Mean ..	C = + 0.500 clamp W.

$C + \Delta i + abr = +\ 0^s.459$ clamp W.

$= -\ 0^s.490$ clamp E.

$\theta = -\ 2^m\ 07^s.100$ at 19^h chronometer-time.

$a = +\ 1^s.00$

$a + \delta = +\ 1^s.02$

NORMAL EQUATIONS.

$$+\ 4.09\,\delta\theta + 2.71\,\delta a + 49.28\,\rho = -\ 6.09$$
$$+\ 9.09\,\delta\theta + 15.57\,\delta a + 2.71\,\rho = -\ 2.07$$
$$+\ 19.18\,\delta\theta + 9.09\,\delta a + 4.09\,\rho = -\ 4.70$$
$$\delta\theta = -\ 0^s.234 \quad \delta a = +\ 0^s.021 \quad \rho = -\ 0^s.105 \text{ (gaining).}$$
$$\Delta t_0 = -\ 2^m\ 07^s.334 \text{ (fast) at } 19^h \text{ chronometer-time.}$$

TABLE 2.—*Detroit, July 8, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a+\delta a)$	Bb	C $(c+\Delta i+abr)$	Rρ	Observed time. h.	m.	s.	Corrected time. s.	Right ascension. h.	m.	s.	Chronometer correction. m.	s.	No. of wires.	p.
		s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	m.	s.		
	Gr. 750, L. C									3	59	07.24			18	0.028
W.	ζ Ophiuchi	+ 0.75	− 0.13	+ 0.49	+ 0.24	16	32	46.47	47.82	16	30	33.66	− 2	14.16	11	1.
W.	ζ Herculis	+ 0.20	− 0.26	+ 0.56	+ 0.23		39	00.05	00.78		36	46.78	− 2	14.00	11	1.
W.	η Herculis	+ 0.07	− 0.16	+ 0.62	+ 0.23		41	01.47	02.23		38	48.09	− 2	14.14	11	1.
W.	49 Herculis	+ 0.44	− 0.14	+ 0.50	+ 0.21		48	51.08	52.09		46	37.82	− 2	14.27	11	1.
W.	κ Ophiuchi	+ 0.51	− 0.15	+ 0.48	+ 0.20		54	13.17	14.21		51	59.98	− 2	14.23	11	1.
W.	ε Herculis	+ 0.21	− 0.24	+ 0.56	+ 0.20		57	56.40	57.13		55	42.94	− 2	14.19	11	1.
E.	α¹ Herculis	+ 0.44	− 0.22	− 0.53	+ 0.18	17	11	25.83	25.70	17	09	11.36	− 2	14.34	11	1.
E.	π Herculis	+ 0.11	− 0.32	− 0.64	+ 0.17		13	08.21	07.53		10	53.27	− 2	14.26	11	1.
E.	α Ophiuchi	+ 0.47	− 0.32	− 0.52	+ 0.14		31	37.03	36.80		29	22.67	− 2	14.13	11	1.
E.	β Ophiuchi	+ 0.57	− 0.15	− 0.51	+ 0.13		39	47.76	47.80		37	33.45	− 2	14.35	11	1.
E.	γ Ophiuchi	+ 0.59	− 0.23	− 0.51	+ 0.12		44	07.62	07.59		41	53.31	− 2	14.28	11	1.
E.	θ Herculis	+ 0.10	− 0.37	− 0.64	+ 0.11		54	24.69	23.89		52	09.53	− 2	14.36	11	1.
E.	67 Ophiuchi	+ 0.59	− 0.23	− 0.51	+ 0.10		56	53.16	53.11		54	38.95	− 2	14.16	11	1.
	δ Urs. Min									18	11	27.43			14	0.019
	λ Urs. Min									19	45	26.87			15	0.001
E.	α² Capricorni	+ 0.78	− 0.14	− 0.52	− 0.12	20	13	38.77	38.77	20	11	24.52	− 2	14.25	11	1.
E.	γ Cygni	+ 0.05	− 0.32	− 0.66	− 0.13		20	11.70	10.64		17	56.52	− 2	14.12	11	1.
E.	π Capricorni	+ 0.85	− 0.09	− 0.54	− 0.13		22	42.12	42.21		20	27.91	− 2	14.30	11	1.
E.	ε Delphini	+ 0.49	− 0.16	− 0.52	− 0.15		29	44.16	43.82		27	29.55	− 2	14.27	11	1.
E.	α Delphini	+ 0.43	− 0.17	− 0.53	− 0.16		36	19.32	18.89		34	04.63	− 2	14.26	11	1.
W.	γ² Delphini	+ 0.43	− 0.18	+ 0.50	− 0.17	20	43	19.97	20.55	20	41	06.23	− 2	14.32	11	1.
W.	μ Aquarii	+ 0.74	− 0.17	+ 0.48	− 0.18		48	24.95	25.82		46	11 51	− 2	14.31	11	1.
W.	ν Cygni	+ 0.03	− 0.26	+ 0.63	− 0.19		54	56.86	57.07		52	43.04	− 2	14.03	11	1.
W.	61¹ Cygni	+ 0.09	− 0.25	+ 0.61	− 0.20	21	03	45.89	46.14	21	01	31.99	− 2	14.15	11	1.
W.	ζ Cygni	+ 0.24	− 0.22	+ 0.55	− 0.21		10	04.32	04.68		07	50.55	− 2	14.13	11	1.
	1 Draconis, L. C									9	19	43.37			13	0.120

s.
From Gr. 750, L. C., $C=+0.534$ clamp W.
δ Urs. Min., $C=+0.538$ clamp W.
λ Urs. Min., $C=+0.500$ clamp W.
1 Draconis, L. C., $C=+0.506$ clamp W.

Mean......... $C=+0.519$
$C+\Delta i+abr=+0.478$ clamp W.
$=-0.509$ clamp E.
$\theta=-2^{m}.\ 13^{s}.700$ at 19^{h} chronometer-time.
$a=+\ 1^{s}.00$
$a+\delta a=+\ 0^{s}.923$

NORMAL EQUATIONS.

$$-\ 6.34\,\delta\theta-\ 1.94\,\delta a+74.31\,\rho=-\ 3.77$$
$$+10.62\,\delta\theta+16.80\,\delta a-\ 1.94\,\rho=-\ 6.56$$
$$+23.17\,\delta\theta+10.62\,\delta a-\ 6.34\,\rho=-12.14$$

$\delta\theta=-0^{s}.517$ $\delta a=-0^{s}.073$ $\rho=-0^{s}.097$ (gaining).
$\Delta t_0=-2^{m}.\ 14^{s}.216$ (fast) at 19^{h} chronometer-time.

TABLE 3.—*Olney, Ill., July 26, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a+\delta a)$	B b	C $(c+\Delta i+abr)$	R ρ	Observed time. h.	m.	s.	Corrected time. s.	Right ascension. h.	m.	s.	Chronometer correction. m.	s.	No. of wires.	P.
		s.	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*		
	δ Urs. Min	....	....	....	....	....			....	18	11	23.76	....		14	0.019
W.	1 Aquilæ	− 0.94	+ 0.04	+ 0.84	+ 0.05	18	27	33.37	33.36		28	41.45	+ 1	08.09	11	1.
W.	α Lyræ	− 0.00	+ 0.13	+ 1.07	+ 0.05		31	44.13	45.38		32	53.85	+ 1	08.47	11	1.
W.	110 Herculis	− 0.43	+ 0.12	+ 0.89	+ 0.05		39	22.05	22.68		40	30.88	+ 1	08.20	11	1.
W.	β Lyræ	− 0.15	+ 0.12	+ 1.00	+ 0.04		44	30.91	31.92		45	40.20	+ 1	08.28	11	1.
W.	θ^1 Serpentis	− 0.73	+ 0.09	+ 0.83	+ 0.04		49	07.73	07.96		50	16.17	+ 1	08.21	11	1.
W.	ε Aquilæ	− 0.53	+ 0.11	+ 0.86	+ 0.04		53	02.92	03.40		54	11.60	+ 1	08.20	11	1.
E.	ζ Aquilæ	− 0.56	+ 0.10	− 0.89	+ 0.04		58	47.85	46.54		59	54.60	+ 1	08.06	11	1.
E.	ι Lyræ	− 0.08	+ 0.17	− 1.07	+ 0.04	19	01	55.47	54.53	19	03	02.52	+ 1	07.99	11	1.
E.	ω Aquilæ	− 0.60	+ 0.12	0.88	+ 0.03		11	05.30	03.97		12	12.04	+ 1	08.07	11	1.
E.	δ Aquilæ	− 0.75	+ 0.11	− 0.87	+ 0.03		18	21.26	19.78		19	27.79	+ 1	08.01	11	1.
E.	β Cygni	− 0.28	+ 0.07	− 0.98	+ 0.03		24	47.01	45.85		25	54.10	+ 1	08.25	11	1.
E.	κ Aquilæ	− 0.93	+ 0.04	− 0.87	+ 0.02		29	20.78	19.04		30	27.08	+ 1	08.04	11	1.
	λ Urs. Min	....	....	....	....	....			....		45	23.24	....		11	0.001
	1 Draconis, L. C	....	....	....	....	....			....	9	19	42.92	....		13	0.120
E.	ε Pegasi	− 0.64	+ 0.17	− 0.88	− 0.03	21	37	11.67	10.29	21	38	18.47	+ 1	08.18	11	1.
E.	μ Capricorni	− 1.05	+ 0.11	− 7.83	− 0.03		45	46.92	38.12		46	46.13	+ 1	08.01	10	0.990
E.	20 Pegasi	− 0.58	+ 0.22	− 0.89	− 0.03		54	08.68	07.40		55	15.46	+ 1	08.06	11	1.
E.	α Aquarii	− 0.81	+ 0.14	− 0.87	− 0.04		58	31.44	29.86		59	38.07	+ 1	08.21	11	1.
E.	θ Pegasi	− 0.70	+ 0.16	− 0.87	− 0.04	22	03	02.81	01.36	22	04	09.61	+ 1	08.25	11	1.
E.	θ Aquarii	− 0.94	+ 0.17	− 0.88	− 0.04		09	24.55	22.86		10	30.90	+ 1	08.04	11	1.
W.	γ Aquarii	− 0.83	+ 0.11	+ 0.83	− 0.04	22	14	20.03	20.10	22	15	28.27	+ 1	08.17	11	1.
W.	π Aquarii	− 0.79	+ 0.14	+ 0.83	− 0.04		18	01.40	01.54		19	09.70	+ 1	08.16	11	1.
W.	η Aquarii	− 0.81	+ 0.13	+ 0.83	− 0.05		28	03.84	03.94		29	12.13	+ 1	08.19	11	1.
W.	ζ Pegasi	− 0.62	+ 0.14	+ 0.85	− 0.05		34	20.86	21.18		35	29.29	+ 1	08.11	11	1.
W.	λ Pegasi	− 0.38	+ 0.11	+ 0.90	− 0.05		39	36.97	37.55		40	45.84	+ 1	08.29	11	1.
W.	μ Pegasi	− 0.36	+ 0.05	+ 0.91	− 0.05		43	04.58	05.13		44	13.41	+ 1	08.28	11	1.
	Carr. 3525	....	....	....	....	....			....	22	55	25.01	....		14	0.025

	July 26.	July 28.	July 29.	July 30.
	s.	*s.*	*s.*	*s.*
From δ Urs. Min.,	C = + 0.921	+ 0.871	+ 0.804	+ 0.873
λ Urs. Min.,	C = + 0.902	+ 0.900	+ 0.880	+ 0.842
1 Draconis.,	C = + 0.925	+ 0.826	+ 0.875	
Carr. 3525,	C = + 0.849	+ 0.850	+ 0.912	+ 0.780
32 Camelopardalis,	C = ...	....	....	+ 0.993

Mean of the four nights, C = + 0.875 clamp W.

$C+\Delta i+abr = +0.833$ clamp W.

$= -0.806$ clamp E.

$\theta = 1^m\ 07^s.700$ at $20^h.5$ chronometer-time.

$a = -\ 1.000$

$a+\delta a = -\ 1.276$

NORMAL EQUATIONS.

$$+\ 2.03\,\delta\theta + \ 4.79\,\delta a + 66.29\,\rho = -2.11$$
$$+11.64\,\delta\theta + 16.70\,\delta a + \ 4.79\,\rho = +0.61$$
$$+24.15\,\delta\theta + 11.64\,\delta a + \ 2.03\,\rho = +7.82$$

$\delta\theta = +0^s.460 \quad \delta a = -0^s.276 \quad \rho = -0^s.0025$ (gaining).

$\Delta t = +1^m.08^s.160$ (slow) at $20^h.5$ chronometer-time.

Table 4.—*Olney, Ill., July 28, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a+\delta a)$	B b	C $(c+\Delta i+abr)$	R ρ	Observed time.	Corrected time.	Right ascension.	Chronometer correction.	No. of wires.	p.
		s.	s.	s.	s.	h. m. s.	s.	h. m. s.	s.		
	δ Urs. Min.	....	....	....	....	....	....	18 11 23.20	....	13	0.019
W.	1 Aquilæ	− 0.88	+ 0.03	+ 0.84	+ 0.15	18 29 24.29	24.43	28 41.45	− 42.98	11	1.
W.	α Lyræ	− 0.00	+ 0.15	+ 1.07	+ 0.14	33 35.26	36.62	32 53.84	− 42.78	11	1.
W.	110 Herculis	− 0.40	+ 0.16	+ 0.89	+ 0.13	41 13.10	13.88	40 30.87	− 43.01	11	1.
W.	β Lyræ	− 0.14	+ 0.13	+ 1.00	+ 0.12	46 22.04	23.15	45 40.19	− 42.96	11	1.
W.	θ Serpentis	− 0.68	+ 0.10	+ 0.83	+ 0.12	50 58.74	59.11	50 16.17	− 42.94	11	1.
W.	ε Aquilæ	− 0.50	+ 0.11	+ 0.86	+ 0.11	54 53.91	54.49	54 11.60	− 42.89	11	1.
E.	ζ Aquilæ	− 0.52	+ 0.11	− 0.89	+ 0.11	19 00 38.88	37.69	59 54.60	− 43.09	11	1.
E.	ι Lyræ	− 0.07	+ 0.24	− 1.07	+ 0.10	03 46.41	45.61	19 03 02.51	− 43.10	11	1.
E.	ω Aquilæ	− 0.56	+ 0.19	− 0.88	+ 0.09	12 56.29	55.13	12 12.04	− 43.09	11	1.
E.	δ Aquilæ	− 0.70	+ 0.16	− 0.87	+ 0.08	20 12.32	11.00	19 27.80	− 43.20	11	1.
E.	β Cygni	− 0.26	+ 0.17	− 0.98	+ 0.08	26 38.18	37.19	25 54.10	− 43.09	11	1.
E.	κ Aquilæ	− 0.87	+ 0.11	− 0.87	+ 0.07	31 11.89	10.33	30 27.09	− 43.24	11	1.
	λ Urs. Min.	....	....	....	....	....	....	45 22.39	....	11	0.0 1
	1 Draconis, L. C	....	....	....	....	....	....	9 19 42.91	....	13	0.120
E.	ξ Aquarii	− 0.88	+ 0.08	− 0.88	− 0.08	21 32 07.61	05.85	21 31 22.74	− 43.11	11	1.
E.	ε Pegasi	− 0.59	+ 0.09	− 0.88	− 0.08	39 02.89	01.43	38 18.50	− 42.93	11	1.
E.	μ Capricorni	− 0.98	+ 0.07	− 0.89	− 0.09	47 31.14	29.25	46 46.16	− 43.09	11	1.
E.	20 Pegasi	− 0.54	+ 0.13	− 0.89	− 0.10	55 59.94	58.54	55 15.49	− 43.05	11	1.
E.	α Aquarii	− 0.76	+ 0.10	− 0.87	− 0.11	22 00 22.82	21.18	59 38.10	− 43.08	11	1.
E.	θ Pegasi	− 0.66	+ 0.10	− 0.87	− 0.11	04 54.14	52.60	22 04 09.64	− 42.96	11	1.
E.	θ Aquarii	− 0.88	+ 0.08	− 0.88	− 0.12	11 15.77	13.97	10 30.94	− 43.03	11	1.
W.	γ Aquarii	− 0.78	+ 0.10	+ 0.83	− 0.13	22 16 11.29	11.31	22 15 28.31	− 43.00	11	1.
W.	π Aquarii	− 0.74	+ 0.13	+ 0.83	− 0.13	19 52.65	52.74	19 09.74	− 43.00	11	1.
W.	η Aquarii	− 0.76	+ 0.15	+ 0.83	− 0.14	.. 29 55.12	55.20	29 12.17	− 43.03	11	1.
W.	ζ Pegasi	− 0.58	+ 0.15	+ 0.85	− 0.15	36 12.08	12.30	35 29.33	− 42.97	11	1.
W.	λ Pegasi	− 0.35	+ 0.19	+ 0.90	− 0.16	41 28.28	28.86	40 45.88	− 42.98	11	1.
W.	μ Pegasi	− 0.38	+ 0.20	+ 0.91	− 0.16	44 55.83	56.45	44 13.45	− 43.00	11	1.
	Carr. 3525	....	....	....	....	....	....	55 25.24	....	15	0.025

s.
$C + \Delta i + 'abr = +$ 0.833 clamp W. (See Table 3.)
$= -$ 0.866 clamp E.
$\theta = -$ 42.60 at 20h.5 chronometer-time.
$a = -$ 1.00
$a + \delta a = -$ 1.194

NORMAL EQUATIONS.

$$+ 3.82\,\delta\theta + 5.94\,\delta a + 67.48\,\rho = - 7.62$$
$$+ 12.39\,\delta\theta + 17.26\,\delta a + 5.94\,\rho = - 8.98$$
$$+ 25.16\,\delta\theta + 12.39\,\delta a + 3.82\,\rho = - 13.24$$
$$\delta\theta = -0^s.421, \quad \delta a = -0^s.194, \quad \rho = -0^s.072 \text{ (gaining)},$$
$$\Delta t_0 = -43^s.021 \text{ (fast) at } 20^h.5 \text{ chronometer-time.}$$

TABLE 5.—*Olney, Ill., July 29, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a + \delta a)$	B b	C $(c + \Delta i + abr)$	R ρ	Observed time. h.	m.	s.	Corrected time.	Right ascension. h.	m.	s.	Chronometer correction.	No. of wires.	p.
		s.	s.	s.	s.	h.	m.	s.	s.	h.	m.	s.	s.		
	δ Urs. Min									18	11	22.90		13	0.019
W.	1 Aquilæ	− 0.72	+ 0.00	+ 0.84	+ 0.10	18	29	25.14	25.36		28	41.45	− 43.91	11	1.
W.	α Lyræ	− 0.00	+ 0.10	+ 1.07	+ 0.10		33	36.34	37.61		32	53.83	− 43.78	11	1.
W.	110 Herculis	− 0.32	+ 0.02	+ 0.89	+ 0.09		41	14.10	14.78		40	30.87	− 43.91	11	1.
W.	β Lyræ	− 0.11	− 0.02	+ 1.00	+ 0.08		46	22.79	23.74		45	40.18	− 43.56	11	1.
W.	θ^1 Serpentis	− 0.55	+ 0.07	+ 0.83	+ 0.08		50	59.59	60.02		50	16.17	− 43.85	11	1.
E.	ζ Aquilæ	− 0.42	+ 0.09	− 0.89	+ 0.07	19	00	39.72	38.57		59	54.60	− 43.97	11	1.
E.	ι Lyræ	− 0.06	+ 0.08	− 1.07	+ 0.07		03	47.39	46.41	19	03	02.50	− 43.91	11	1.
E.	ω Aquilæ	− 0.46	+ 0.04	− 0.88	+ 0.06		12	57.16	55.92		12	12.04	− 43.88	11	1.
E.	δ Aquilæ	− 0.57	+ 0.06	− 0.87	+ 0.06		20	13.15	11.83		19	27.80	− 44.03	11	1.
E.	β Cygni	− 0.21	+ 0.07	− 0.98	+ 0.05		26	39.08	38.01		25	54.10	− 43.91	11	1.
E.	κ Aquilæ	− 0.70	+ 0.05	− 0.87	+ 0.05		31	12.67	11.20		30	27.09	− 44.11	11	1.
	λ Urs. Min										45	21.86		12	0.001
	1 Draconis, L. C									9	19	42.91		13	0.120
E.	ξ Aquarii	− 0.72	+ 0.01	− 0.88	− 0.05	21	32	08.42	06.78	21	31	22.76	− 44.02	11	1.
E.	ε Pegasi	− 0.48	+ 0.07	− 0.88	− 0.06		39	03.80	02.45		38	18.52	43.93	11	1.
E.	μ Capricorni	− 0.80	+ 0.01	− 0.89	− 0.06		47	31.84	30.10		46	46.18	43.92	11	1.
E.	20 Pegasi	− 0.44	+ 0.05	− 0.89	− 0.07		56	00.85	59.50		55	15.51	43.99	11	1.
E.	α Aquarii	− 0.62	+ 0.06	− 0.87	− 0.07	22	00	23.54	22.04		59	38.12	43.92	11	1.
E.	θ Pegasi	− 0.53	+ 0.04	− 0.87	− 0.08		04	55.08	53.64	22	04	09.66	43.98	11	1.
E.	θ Aquarii	− 0.72	+ 0.03	− 0.88	− 0.08		11	16.54	14.89		10	30.96	43.93	11	1.
W.	γ Aquarii	− 0.63	+ 0.06	+ 0.83	− 0.09	22	16	11.97	12.14	22	15	28.32	− 43.82	11	1.
W.	π Aquarii	− 0.60	+ 0.07	+ 0.83	− 0.09		19	53.39	53.60		19	09.76	− 43.84	11	1.
W.	η Aquarii	− 0.62	+ 0.06	+ 0.83	− 0.10		29	55.86	56.03		29	12.19	− 43.84	11	1.
W.	ζ Pegasi	− 0.47	+ 0.08	+ 0.85	− 0.10		36	12.88	13.24		35	29.35	− 43.89	11	1.
W.	λ Pegasi	− 0.29	+ 0.09	+ 0.90	− 0.11		41	28.90	29.49		40	45.90	− 43.59	11	1.
W.	μ Pegasi	− 0.27	+ 0.09	+ 0.91	− 0.11		44	56.74	57.36		44	13.47	− 43.89	11	1.
	Carr. 3525									22	55	25.34		15	0.025

$C + \Delta i + abr = +$ 0.833 s. clamp W. (See Table 3.)
$= -$ 0.866 clamp E.
$\theta = -$ 43.50 at $20^h.5$ chronometer-time.
$a = -$ 0.80
$a + \delta a = -$ 0.970

NORMAL EQUATIONS.

$$+ 5.40\,\delta\theta + 6.62\,\delta a + 64.98\,\rho = - 6.44$$
$$+ 11.97\,\delta\theta + 17.08\,\delta a + 6.62\,\rho = - 7.86$$
$$+ 24.16\,\delta\theta + 11.97\,\delta a + 5.40\,\rho = - 11.64$$

$\delta\theta = - 0^s.386$, $\delta a = - 0^s.170$, $\rho = - 0^s.049$ (gaining).
$\Delta t_0 = - 43^s.886$ (fast) at $20^h.5$ chronometer-time.

TABLE 6.—*Olney, Ill., July 30, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A ($a+\delta a$)	B b	C ($c+\Delta i+abr$)	R ρ	Observed time.	Corrected time.	Right ascension.	Chronometer correction.	No. of wires.	p.
		s.	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*h. m. s.*	*s.*		
	δ Urs. Min	....	....	....	....	....	....	18 11 22.58	....	13	0.019
W.	1 Aquilæ	− 0.71	+ 0.14	+ 0.84	+ 0.20	18 29 25.49	25.96	28 41.45	− 44.51	11	1.
W.	α Lyræ	− 0.00	+ 0.24	+ 1.07	+ 0.20	33 36.53	38.04	32 53.83	− 44.21	11	1.
W.	110 Herculis	− 0.32	+ 0.23	+ 0.89	+ 0.19	41 14.49	15.48	40 30.87	− 44.61	11	1.
W.	β Lyræ	− 0.11	+ 0.32	+ 1.00	+ 0.18	46 23.25	24.64	45 40.18	− 44.46	11	1.
W.	θ Serpentis	− 0.55	+ 0.19	+ 0.83	+ 0.18	51 00.05	00.70	50 16.17	− 44.53	11	1.
W.	ϵ Aquilæ	− 0.40	+ 0.22	+ 0.86	+ 0.17	54 55.15	56.00	54 11.60	− 44.40	11	1.
E.	ζ Aquilæ	− 0.42	+ 0.28	− 0.89	+ 0.17	19 00 40.11	39.25	59 54.60	− 44.65	11	1.
E.	ι Lyræ	− 0.06	+ 0.33	− 1.07	+ 0.16	03 47.58	46.94	19 03 02.50	− 44.44	11	1.
E.	ω Aquilæ	− 0.45	+ 0.22	− 0.88	+ 0.15	12 57.69	56.73	12 12.04	− 44.69	11	1.
E.	δ Aquilæ	− 0.56	+ 0.22	− 0.87	+ 0.15	20 13.68	12.62	19 27.81	− 44.81	11	1.
E.	β Cygni	− 0.21	+ 0.26	− 0.98	+ 0.14	26 39.37	38.58	25 54.10	− 44.48	11	1.
E.	κ Aquilæ	− 0.70	+ 0.16	− 0.87	+ 0.13	31 13.07	11.79	30 27.10	− 44.69	11	1.
	λ Urs. Min	....	....	....	....	....	....	45 21.27	....	12	0.001
	Carr. 3525	....	....	....	....	....	....	22 55 25.45	....	11	0.024
E.	τ Pegasi	− 0.28	+ 0.20	− 0.94	− 0.12	23 15 28.49	27.35	23 14 42.58	− 44.77	11	1.
E.	υ Pegasi	− 0.29	+ 0.20	− 0.94	− 0.12	20 09.93	08.77	19 24.07	− 44.70	11	1.
E.	θ Piscium	− 0.53	+ 0.16	− 0.87	− 0.13	22 39.51	38.14	21 53.48	− 44.66	11	1.
E.	72 Pegasi	− 0.16	+ 0.22	− 0.92	− 0.13	28 46.48	45.49	28 00.70	− 44.79	11	1.
E.	ι Piscium	− 0.54	+ 0.16	− 0.87	− 0.14	84 33.35	31.96	33 47.34	− 44.62	11	1.
W.	ϕ Pegasi	− 0.35	+ 0.15	+ 0.88	− 0.15	23 47 07.46	07.99	23 46 23.55	− 44.44	11	1.
W.	ω Piscium	− 0.52	+ 0.13	+ 0.84	− 0.16	53 53.62	53.91	53 09.49	− 44.42	11	1.
W.	α Andromedæ	− 0.20	+ 0.14	+ 0.95	− 0.17	04 02 55.28	56.00	04 02 11.64	− 44.36	11	1.
W.	γ Pegasi	− 0.41	+ 0.18	+ 0.86	− 0.18	07 47.90	48.35	07 03.87	− 44.48	11	1.
W.	ι Ceti	− 0.73	+ 0.15	+ 0.84	− 0.18	14 03.67	03.75	13 19.28	− 44.47	11	1.
W.	12 Ceti	− 0.66	+ 0.17	+ 0.84	− 0.20	24 39.56	39.71	23 55.27	− 44.44	11	1.
	32^2 Camelop., L. C	....	....	....	....	....	....	12 48 12.85	....	13	0.038

$$\begin{aligned} C+\Delta i+abr &= +\ 0^s.833 \text{ clamp W. (See Table 3.)} \\ &= -\ 0.866 \text{ clamp E.} \\ \theta &= -\ 44.00 \text{ at } 21^h.5 \text{ chronometer-time.} \\ a &= -\ 0.90 \\ a+\delta a &= -\ 0.963 \end{aligned}$$

NORMAL EQUATIONS.

$$-\ 4.99\,\delta\theta + 1.51\,\delta a + 136.16\,\rho = -\ 6.53$$
$$+\ 9.39\,\delta\theta + 13.26\,\delta a + 1.51\,\rho = -\ 5.98$$
$$+\ 23.08\,\delta\theta + 9.39\,\delta a - 4.99\,\rho = -\ 12.66$$
$$\delta\theta = -\ 0^s.538,\quad \delta a = -\ 0^s.063,\quad \rho = -\ 0^s.067 \text{ (gaining).}$$
$$\Delta t_0 = -\ 44^s.538 \text{ (fast) at } 21^h.5 \text{ chronometer-time.}$$

TABLE 7.—*Detroit, Mich., August 26, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a+\delta a)$	B b	C $(c+\Delta i+abr)$	R ρ	Observed time.			Corrected time.	Right ascension.			Chronometer correction.	No. of wires.	p.
		s.	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*		
	δ Urs. Min									18	11	13.53		13	0.019
W.	1 Aquilæ	− 6.29	− 0.00	+ 0.57	+ 0.24	18	29	17.86	12.38		28	41.25	− 31.13	11	1.
W.	110 Herculis	− 3.20	− 0.00	+ 0.60	+ 0.22		41	03.98	01.60		40	30.64	− 30.96	11	1.
W.	β Lyræ	− 1.52	− 0.00	+ 0.68	+ 0.21		46	11.39	10.76		45	39.87	− 30.89	11	1.
W.	ϵ Aquilæ	− 3.84	− 0.06	+ 0.59	+ 0.19		54	45.43	42.31		54	11.42	− 30.89	11	1.
E.	ζ Aquilæ	− 3.97	+ 0.03	− 0.61	+ 0.18	19	00	29.80	25.43		59	54.42	− 31.01	11	1.
E.	ι Lyræ	− 1.11	− 0.04	− 0.74	+ 0.17		03	34.67	32.95	19	03	02.24	− 30.71	11	1.
E.	ω Aquilæ	− 4.22	− 0.10	− 0.61	+ 0.16		12	47.50	42.73		12	11.92	− 30.81	11	1.
E.	δ Aquilæ	− 5.12	− 0.06	− 0.60	+ 0.14		20	04.31	58.67		19	27.70	− 30.97	11	1.
E.	β Cygni	− 2.29	− 0.15	− 0.67	+ 0.13		26	27.65	24.67		25	53.94	− 30.73	11	1.
E.	κ Aquilæ	− 6.19	− 0.09	− 0.60	+ 0.12		31	04.70	57.94		30	27.04	− 30.90	11	1.
	λ Urs. Min										45	02.08		9	0.001
	1 Draconis, L. C									9	19	43.89		15	0.124
E.	ξ Aquarii	− 6.30	− 0.02	− 0.60	− 0.12	21	32	00.90	53.86	21	31	23.00	− 30.86	11	1.
E.	ϵ Pegasi	− 4.44	+ 0.04	− 0.60	− 0.14		38	54.72	49.58		38	18.76	− 30.82	11	1.
E.	μ Capricorni	− 6.91	− 0.01	− 0.62	− 0.16		47	24.91	17.21		46	46.48	− 30.73	11	1.
E.	20 Pegasi	− 4.09	+ 0.02	− 0.61	− 0.17		55	51.55	46.70		55	15.81	− 30.89	11	1.
E.	α Aquarii	− 5.51	+ 0.05	− 0.60	− 0.18	22	00	15.59	09.35		59	38.42	− 30.93	11	1.
E.	θ Pegasi	− 4.84	+ 0.03	− 0.60	− 0.19		04	46.47	40.87	22	04	09.99	− 30.88	11	1.
E.	θ Aquarii	− 6.29	+ 0.03	− 0.60	− 0.20		11	09.25	02.19		10	31.31	− 30.88	11	1.
W.	γ Aquarii	− 5.62	− 0.04	+ 0.57	− 0.21	22	16	04.95	59.65	22	15	28.69	− 30.96	11	1.
W.	π Aquarii	− 5.34	− 0.05	+ 0.57	− 0.22		19	46.12	41.08		19	10.11	− 30.97	11	1.
W.	η Aquarii	− 5.49	− 0.07	+ 0.57	− 0.24		29	48.68	43.45		29	12.57	− 30.88	11	1.
W.	ζ Pegasi	− 4.35	− 0.06	+ 0.58	− 0.25		36	04.78	00.70		35	29.75	− 30.95	11	1.
W.	λ Pegasi	− 2.90	− 0.06	+ 0.61	− 0.26		41	19.76	17.15		40	46.34	− 30.81	11	1.
W.	μ Pegasi	− 2.77	− 0.06	+ 0.62	− 0.27		44	47.31	44.83		44	13.91	− 30.92	11	1.
	Carr. 3525									22	55	27.19		14	0.025

	Aug. 26.	Aug. 27.
	s.	*s.*
From δ Urs. Min., C =	+ 0.651	+ 0.584
λ Urs. Min., C =	+ 0.606	+ 0.633
1 Draconis., C =	+ 0.599	+ 0.565
Carr. 3525, C =	+ 0.618	+ 0.603

Mean of both nights, $C = +0^s.607$ clamp W.

$$C+\Delta i+abr = +\ 0^s.566 \text{ clamp W.}$$
$$= -\ 0.597 \text{ clamp E.}$$
$$\theta = -\ 30.53 \text{ at } 20^h.5 \text{ chronometer-time.}$$
$$a = -\ 8.00$$
$$a+\delta a = -\ 8.047$$

NORMAL EQUATIONS.

$$+\ 7.36\,\delta\theta + 7.07\,\delta a + 61.05\,\rho = -10.40$$
$$+\ 13.05\,\delta\theta + 17.28\,\delta a + 7.07\,\rho = -\ 6.41$$
$$+\ 23.17\,\delta\theta + 13.05\,\delta a + 7.36\,\rho = -\ 9.92$$
$$\delta\theta = -0^s.363,\quad \delta a = -0^s.047,\quad \rho = -0^s.121 \text{ (gaining).}$$
$$\Delta t_0 = -30^s.893 \text{ (fast) at } 20^h.5 \text{ chronometer-time.}$$

TABLE 8.—*Detroit, Mich., August 27, 1879.—Observer, Lieut. P. M. Price.*

Clamp.	Stars.	A $(a + \delta a)$	B b.	C $(c + \Delta i + abr)$.	R ρ.	Observed time.	Corrected time.	Right ascension.	Chronometer correction.	No. of wires.	p.
		s.	*s.*	*s.*	*s.*	*h. m. s.*	*s.*	*h. m. s.*	*s.*		
....	δ Urs. Min							18 11 13.10		16	0.020
W.	1 Aquilæ	— 7.59	— 0.08	+ 0.57	+ 0.21	18 29 21.30	14.41	28 41.24	— 33.17	11	1.
W.	α Lyræ	— 0.80	— 0.15	+ 0.73	+ 0.21	33 26.37	26.36	32 53.42	— 32.94	11	1.
W.	110 Herculis	— 3.86	— 0.12	+ 0.60	+ 0.19	41 06.90	03.71	40 30.63	— 33.08	11	1.
W.	β Lyræ	— 1.83	— 0.16	+ 0.68	+ 0.18	46 14.00	12.87	45 39.85	— 33.02	11	1.
W.	θ^1 Serpentis	— 6.02	— 0.11	+ 0.57	+ 0.17	50 54.45	49.06	50 16.01	— 33.05	11	1.
W.	ϵ Aquilæ	— 4.63	— 0.12	+ 0.59	+ 0.17	54 48.43	44.44	54 11.41	— 33.03	11	1.
E.	ζ Aquilæ	— 4.78	— 0.04	— 0.61	+ 0.16	19 00 32.79	27.52	59 54.41	— 33.11	11	1.
E.	ι Lyræ	— 1.34	— 0.16	— 0.74	+ 0.15	03 37.14	35.05	19 03 02.22	— 32.83	11	1.
E.	ω Aquilæ	— 5.09	— 0.03	— 0.61	+ 0.14	12 50.52	44.93	12 11.91	— 33.02	11	1.
E.	δ Aquilæ	— 6.17	— 0.07	— 0.60	+ 0.12	20 07.47	00.75	19 27.69	— 33.06	11	1.
E.	β Cygni	— 2.76	— 0.08	— 0.67	+ 0.11	26 30.29	26.89	25 53.93	— 32.96	11	1.
E.	κ Aquilæ	— 7.46	— 0.05	— 0.60	+ 0.10	31 08.13	00.12	30 27.03	— 33.09	11	1.
....	λ Urs. Min							45 01.01		10	0.001
....	1 Draconis L. C							9 19 43.95		13	0.121
E.	ξ Aquarii	— 7.60	— 0.10	— 0.60	— 0.11	21 32 04.38	55.97	21 31 23.00	— 32.97	11	1.
E.	ϵ Pegasi	— 5.35	— 0.07	— 0.60	— 0.12	38 57.87	51.73	38 18.76	— 32.97	11	1.
E.	μ Capricorni	— 8.33	— 0.04	— 0.62	— 0.14	47 28.60	19.47	46 46.48	— 32.99	11	1.
E.	20 Pegasi	— 4.93	— 0.08	— 0.61	— 0.15	55 54.56	48.79	55 15.82	— 32.97	11	1.
E.	α Aquarii	— 6.64	— 0.08	— 0.60	— 0.16	22 00 18.91	11.43	59 38.43	— 33.00	11	1.
E.	θ Pegasi	— 5.83	— 0.14	— 0.60	— 0.17	04 49.72	42.98	22 04 10.00	— 32.90	11	1.
E.	θ Aquarii	— 7.59	— 0.11	— 0.60	— 0.18	11 12.76	04.28	10 31.32	— 32.96	11	1.
W.	γ Aquarii	— 6.78	— 0.11	+ 0.57	— 0.19	22 16 08.28	01.77	22 15 28.70	— 33.07	11	1.
W.	π Aquarii	— 6.43	— 0.13	+ 0.57	— 0.19	19 49.39	43.21	19 10.12	— 33.09	11	1.
W.	η Aquarii	— 6.62	— 0.11	+ 0.57	— 0.21	29 52.02	45.65	29 12.58	— 33.07	11	1.
W.	ζ Pegasi	— 5.24	— 0.10	+ 0.58	— 0.22	36 07.87	02.89	35 29.76	— 33.13	11	1.
W.	λ Pegasi	— 3.50	— 0.18	+ 0.61	— 0.23	41 22.60	19.30	40 46.35	— 32.95	11	1.
W.	μ Pegasi	— 3.34	— 0.24	+ 0.62	— 0.24	44 50.04	46.84	44 13.92	— 32.92	11	1.
	Carr. 3525							55 27.21		15	0.025

$C + \Delta i + abr = + 0^s.566$ clamp W. (See Table 7.)
$= - 0^s.597$ clamp E.
$\theta = - 32^s.76$ at $20^h.5$ chronometer-time.
$a = - 9^s.00$
$a + \delta a = - 9^s.70$

NORMAL EQUATIONS.

$$+ 3.78\,\delta\theta + 5.92\,\delta a + 67.52\,\rho = -12.28$$
$$+ 13.72\,\delta\theta + 17.71\,\delta a + 5.92\,\rho = -16.64$$
$$+ 25.17\,\delta\theta + 13.72\,\delta a + 3.78\,\rho = -16.64$$

$\delta\theta = - 0^s.264$, $\delta a = - 0^s.700$, $\rho = - 0^s.106$ (gaining).
$\Delta t_o = - 33.024$ (fast) at $20^h.5$ chronometer-time.

TABLE 9.—*Latitude of Station Parkersburg.*

Star.	Individual results, 1879. Aug. 9. 38° 34′	Aug. 10.	Aug. 11.	Aug. 12.	Aug. 13.	Mean results from each pair = ϕ_1.	No. of observations = n.	Weight of $\phi_1 = p$.	$p\,\phi_1$.	$\phi - \phi_1 = v$.	vv.	$p\,(vv)$.
	″	″	″	″	″	″						
B. A. C. 5552 5619				53.69		53.69	1	2.00	7.38	0.4	0.16	0.32
5652 5706	53.47		53.66	52.62		53.25	3	2.61	8.48	0.0	0.00	0.00
5775 5842	53.15			53.27	53.07	53.16	3	2.61	8.25	0.1	0.01	0.03
5874 5886	53.89		53.98	52.71	53.06	53.41	4	2.71	9.24	0.1	0.01	0.03
5962 5990	53.65		53.24		52.52	53.14	3	2.61	8.20	0.2	0.04	0.10
6068 6082	53.84		53.29	52.77	52.95	53.21	4	2.71	8.70	0.0	0.00	0.00
6129 6150	52.92	51.91	53.12	54.18	54.11	53.25	5	2.78	9.04	0.0	0.00	0.00
6218 6235	49.71	53.32	54.13	52.45	*[59.48]	52.40	4	2.71	6.50	0.9	0.81	2.20
6355 6365	53.49	55.45	54.04	55.25	54.52	54.55	5	2.78	12.65	1.3	1.69	4.70
6429 6475	52.72	49.63	51.29	54.90	53.87	52.48	5	2.78	6.89	0.8	0.64	1.78
6581 6599		54.43	52.85	52.95	52.94	53.29	4	2.71	8.92	0.0	0.00	0.00
6656 6698	52.90	52.77	52.60	53.51	52.72	52.90	5	2.78	8.06	0.4	0.16	0.44
6714 6721	52.50	56.94	53.03	55.46	54.78	54.54	5	2.78	12.62	1.2	1.44	4.00
6745 6777	52.79	53.85	53.47	53.37	52.79	53.25	5	2.78	9.04	0.0	0.00	0.00
6817 6875	53.64	53.89	53.38	53.94	54.46	53.86	5	2.78	10.73	0.6	0.36	1.00
6996 7006	53.57	53.47	48.92	55.25		52.80	4	2.71	7.59	0.5	0.25	0.68
7073 7101	53.29	53.19	54.01			53.50	3	2.61	9.14	0.2	0.04	0.10
7112 7131		54.32		53.26		53.79	2	2.42	9.17	0.5	0.25	0.60
7161 7164	52.65	53.37		53.68	55.95	53.91	4	2.71	10.60	0.6	0.36	0.98
7204 7241	57.75	52.45		52.80	52.47	53.87	4	2.71	10.49	0.6	0.36	0.98
7313 7336	52.60	51.88			53.16	52.58	3	2.61	6.73	0.7	0.49	1.28

7383												
C. S. 1934		51.43				51.43	1	2.00	2.86	1.9	3.61	7.22
B. A. C. 7465												
7501	51.67	51.45		52.80		51.97	3	2.61	5.14	1.3	1.69	4.41
7602												
7614	53.84	52.20				53.02	2	2.42	7.31	0.3	0.09	0.22
7705												
7721		53.10		53.95	55.17	54.07	3	2.61	10.62	0.8	0.64	1.67
7705												
7731	50.28					50.28	1	2.00	0.56	3.0	9.00	18.00
7731												
Gr. 3717		52.14		51.62	53.07	52.28	3	2.61	5.95	1.0	1.00	2.61
B. A. C. 7879												
7901	54.08					54.08	1	2.00	8.16	0.8	0.64	1.28
7880												
7901		52.32		52.10	53.45	52.62	3	2.61	6.84	0.7	0.49	1.28
8058												
8141	53.38			55.31	54.03	54.24	3	2.61	11.07	1.0	1.00	2.61
8211												
8245	54.11			54.17	53.92	54.07	3	2.61	10.62	0.8	0.64	1.67
C. S. 2176												
B. A. C. 58	54.50	53.01		53.17	53.90	53.64	4	2.71	9.86	0.4	0.16	0.43
166												
197	51.81	52.49		52.21	52.17	52.17	4	2.71	5.88	1.1	1.21	3.28
259												
297	53.00	55.09			53.63	53.91	3	2.61	10.21	0.6	0.36	0.94
330												
345	52.06	53.40		53.21	53.49	53.04	4	2.71	8.24	0.2	0.04	0.11
465												
480		51.92		54.05	55.70	53.89	3	2.61	10.15	0.6	0.36	0.94
501												
516					54.02	54.02	1	2.00	8.04	0.7	0.49	0.98
544												
575		53.49		53.81	52.28	53.19	3	2.61	8.32	0.1	0.01	0.03
Number of pairs on each night	28	27	15	29	27							
Sums								97.94	318.25			66.90
Arithmetical means	53.122	53.072	52.998	53.528	53.634							

* It is probable that an error of 10 divisions of the micrometer head was made in reading or recording this observation, as the result would in that case become 53″.26. This result is therefore rejected in taking the mean.

Arithmetical mean of the 5 nights' work = 38° 34′ 53″.300

ϕ = weighted mean = $\frac{\Sigma(p\,\phi_1)}{\Sigma p}$ = 38° 34′ 53″.248

r_1 = probable error of single result of weight unity = $\pm 0.6745\sqrt{\frac{\Sigma(pvv)}{m-1}} = \pm 0.91$

r = probable error of weighted mean (ϕ) = $\pm \frac{r_1}{\sqrt{\Sigma p}} = \pm 0''.09$

Reduction from latitude-post to station Parkersburg = −0″.045

LATITUDE OF STATION PARKERSBURG = 38° 34′ 53″.203 ± 0″.09

APPENDIX No. 4.

REPORTS OF CHIEFS OF PARTIES.

1.—REPORT OF MR. E. S. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY.
November 4, 1879.

SIR: I have the honor to submit the following report of the measurement of the Olney base line:

I received your orders July 3, 1879, to take charge of the base measuring party, and measure the Olney base line with the Repsold apparatus.

The organization of the party was as follows: Assistant engineers, J. A. Ockerson and E. S. Wheeler; recorders, W. M. Childs, F. W. Stevens, and G. L. Fisher; foreman, Arthur Fortier, and thirteen laborers.

The instruments were sent by special car to Sandefur's Station, on the Grayville and Mattoon Railroad.

I left Detroit July 6 and arrived at the base line July 9. Assistant Engineer Ockerson had been on the ground two days purchasing material for making ends of base line, &c. The remainder of the party arrived July 9. The instruments arrived July 10.

The base line is situated in Fox and Sainte Marie Townships, Jasper County, Illinois. It runs nearly east and west, and is about one mile north of the southern boundary of the county. About one-half of the line was in open prairie, the remainder in cultivated fields. The difference between the highest and lowest points of the line was about 23 feet.

The ends of the line were marked with granite posts, surrounded by three feet of masonry, similar to the marking of the Chicago base-line, which is described on page 1402 of the Report of the Chief of Engineers for 1878, except that the side stones were eight meters from the end stone, and the end stones had small marking brasses similar to the side stones. The line was divided into six nearly equal sections. The sections were marked with stones two feet square and one foot thick, similar to those used in the Chicago base.

The middle section stone was used for the middle base triangulation station. Points in the line 300^{m} apart were determined. This was done in the following way: Targets were placed vertically over the end marks, and the instrument, Young and Son's theodolite No. 156, was placed midway and approximately in line. The angle between the targets was measured, and the distance from the instrument to the line computed and set off. This was done for each 300^{m} point. A portion of this work was done at night with light placed on the targets. This portion of the work was assigned to Assistant Engineer Ockerson. The party were occupied in setting marking stones, preparing the line, and cleaning and adjusting the apparatus, till July 24. The adjustments were all made as in the Chicago base-line. During measurement the zero of the sector arc and the adjustment of the tube-telescope were tested every day. The remaining adjustments were tested every Saturday. The stability of the microscopes was also tested each day. The method was as follows: Two microscopes were read at the two ends of the tube, standing in the usual manner. Then a second reading would be taken with a man standing near one of the microscopes, the difference in the readings on the tube showing the movement of the microscopes. This was repeated many times and in many ways. Twice during the measurement a series of experiments was made to determine the movement of a microscope caused by placing and removing a tube.

The following method is taken from instructions given by General Comstock, September 30, 1878: "* * * Having three microscopes and tube-stands standing at 1, 2, 3 (2 being in the soft place), use 1 and 3 as the stable points to which to refer the motion of 2. To assure the stability, see first that the platform supports are at such distance from the microscopes that no motion of the observer on the platform can change the reading of either 1 or 3 on the tube. * * * Point to the tube with microscopes 1 and 3, and then add gently to tube-stands 1 and 3 a load (symmetrical about the axis of the tube-stand) equal to one-half a tube's weight. Then reread microscopes to detect longitudinal motion. Lateral motion to 0.01^{mm} can be estimated. Being sure that neither the observer's weight on the platform nor the tube-weight on its stand disturbs microscopes 1 and 3, they may be used as reference points. Then make readings as follows: Tube at 1-2 with readings; tube at 2-3 with readings; tube at 1-2 with readings; tube at 2-3 with readings. This makes a set. Several sets should be taken with the men exercising no more than their average care in moving about 2. Then several sets in which they come as near the foot of stand 2 as they ever do when careless."

The weight was added to the tube-stand by placing iron pins symmetrically in the braces of the stand. The weight of tube 1 is 160 pounds.

The order of work, form of record, &c., were the same as at the Chicago base except the parts previously mentioned. The microscopes and tube-trestles were placed on iron pins as at Chicago. The platforms on which the observers stood had projecting pieces attached to their ends to prevent the tube-carriers from stepping within one-half meter of feet of microscope-stands. The cut-offs were made as at the Chicago base, and described on page 1406 of Report of Chief of Engineers, 1878. The microscopes standing over the cut-offs were left undisturbed for a check on the stability of the cut-offs. The apparatus was kept under awnings at all times. The party was detailed as follows: F. W. Stevens placed the microscopes in position, J. A. Ockerson observed at rear end, E. S. Wheeler observed at the forward end, G. L. Fisher recorded at rear end, and W. M. Childs recorded at front end. Whenever a fractional tube was measured at a section-stone, the direct measurement was resumed at the cut-off marking the last full tube. The fractional tubes at the section-stones do not therefore enter into the value of the whole line.

The first measurement was made from west to east, and completed August 22. The second measurement was made from east to west, and was completed September 12. Measuring was done on 32 days. The average number of tubes measured per day, including remeasurements each morning, was 105. The greatest number measured in a single day was 168.

A profile of the base and its mean height above the Ohio and Mississippi Railroad at Olney, Ill., were carefully determined. This part of the work was assigned to F. W. Stevens. The topography for one-half mile on each side of the base-line was determined. This work was assigned to W. M. Childs.

The party was broken up September 17.

Very respectfully, your obedient servant,

E. S. WHEELER,
Assistant Engineer.

General C. B. COMSTOCK.

2.—REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich., June 8, 1880.

GENERAL: In compliance with your instructions of June 7, I have the honor of making the following report upon field work for the past year.

On the 29th of July last I received instructions to proceed to Parkersburg, Ill., and observe for azimuth on five nights, and when that duty was completed, to join the primary triangulation parties working southward from Chicago.

I arrived at Parkersburg on August 4; Lieut. P. M. Price, Corps of Engineers, had previously been instructed to have three stone posts prepared for use at Olney, Ill., one for an observing post, one for an azimuth mark, and one for permanently marking Parkersburg Station. These stones were received at Parkersburg on the 5th. A site was selected for the station and observations were commenced on the 9th.

Owing to heavy timber in the vicinity, the azimuth mark could not be placed at a greater distance than two miles from the observatory without much cutting. A stone post, 3 feet long and 1 foot square, was set with its top 3 feet below the surface of the ground to mark the geodetic point. The observing post was of limestone, 6 feet long, nearly 2 feet square, and was set over the geodetic point. The azimuth mark was a stone post of the same size as the one marking the geodetic point, set with its top 1.2 feet below the surface of the ground. Seven check-marks were established to determine any movement of the observing post, and four for determining any movement of the azimuth mark. Observations for time and azimuth were made on seven nights and were finished on the 17th of August. As an experiment, observations were made on Polaris in the daytime and referred to a target about 11 miles distant. The angle between the two marks was well measured later in the season.

On the 21st of August I commenced the measurement of primary angles and zenith distances, occupying, successively, stations Paxton, Mayview, Oakland, Casey, Mound, and Parkersburg, completing the season's work at the latter point.

The contractor in building station Parkersburg accidently moved the azimuth post about 1 inch from its position when observations were made in August. Your instructions required a redetermination of the azimuth if either observing post or azimuth mark had moved by as much as 1″ of arc. No movement of the mark could be detected. The displacement of the post slightly exceeded 1″, and the observations were repeated on five nights between November 22 and December 1, from the same center as was used in the August observations. The two series of observations will therefore be comparable without reduction to center.

The primary angles and target corrections at this station were referred to the azimuth center. It was feared that the movement of the observing post had disturbed the stone post beneath it marking the geodetic point. After all of the observations had been completed, the post was removed and the lower stone found about ¼ inch out of place. It was reset exactly under the azimuth center. A common marking stone was set over the permanent mark, its top rising nearly to the surface of the ground.

Each station occupied was referred to a marked section corner by azimuth and distance, and topographical sketches were made of the immediate locality.

The stations occupied were all permanently marked and reference stones set and located. Mr. Charles F. Niles served as recorder during the season. The Troughton & Simms theodolite, No. 1, and Bond & Son sidereal chronometer, No. 220, were used during the season.

The field work was completed on December 2, and I returned to Detroit on the 4th.

Respectfully submitted.

A. R. FLINT,
Assistant Engineer.

General C. B. COMSTOCK.

SUMMARY.

Number of results on standard circumpolar stars, 8 observations each	43
Number of nights for time and azimuth	12
Number of primary triangulation stations occupied	6
Number of primary angles measured	47
Number of zenith distances measured	29

3.—REPORT OF MR. G. Y. WISNER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 8, 1880.

SIR: I have the honor to submit the following report of field work upon which I have been engaged since May 1, 1879:

During May and June I was occupied in Eastern Michigan measuring angles for completing the triangulation east from Hillsdale to Lake Erie.

The line between stations Bunday and Pittsford was found obstructed by heavy timber so that a new station had to be located in Wheatland Township, the locating and building of which delayed the work considerable time.

On the 1st of July my party was transferred to Morgan Park to commence the measurement of angles of the Illinois triangulation south from Chicago. In connection with the other triangulation parties I was engaged on this work until the last of November, when the work was closed up on the line Denver-Parkersburg, and the party returned to Detroit.

During the past winter I have been occupied with the reduction and tabulation of the season's field notes and the least square reduction of the southern section of the Illinois triangulation.

On May 3 of the present year, I left Detroit to observe for latitude at Fairmount and West Base, Ill. I obtained four night's observations at each station and returned to Detroit May 20.

The following is a summary of the season's field work:

MICHIGAN TRIANGULATION.

Number of stations located	1
Number of stations occupied	5
Number of primary angles measured	19
Number of vertical angles measured	15

ILLINOIS TRIANGULATION.

Number of stations occupied	11
Number of primary angles measured	67
Number of vertical angles measured	43
Number of latitude stations occupied	2
Number of pairs of stars observed for latitude	223

Very respectfully submitted.

GEO. Y. WISNER,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

4.—REPORT OF MR. R. S. WOODWARD, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, June 9, 1880.

SIR: In compliance with your instructions, I have the honor to submit the following report on work done by me during the year ending May 1, 1880:

On May 1, 1879, I began work on the triangulation between Lakes Erie and Michigan at station Pittsford. In this system my party occupied stations Pittsford, Cedar Point, Blissfield, Wheatland, and Reading between May 1 and July 11. On the latter date, the triangulation in Michigan being completed, we proceeded to Illinois and began work on the triangulation south from Chicago. In this work we occupied in succession stations Orland, Garden, Kankakee, Spring Creek, Rantoul, Lynn Grove, Westfield, Hunt City, West Base (of Olney Base), Denver, and Onion Hill. The work at the latter station was completed November 23, on which date I left the field and returned to Detroit. Mr. E. S. Davis was recorder for the party from May 1 to August 18, when he was relieved by Mr. E. E. Haskell, who recorded during the remainder of the season. To them and to Mr. John P. Hoffman, observer's attendant during the entire season, my thanks are due for efficient assistance.

Since returning to the office, November 25, I have been engaged chiefly in tabulating results of season's field work and in preparation of manuscript for the final report of the Lake Survey. In the latter work I have been assisted constantly by Mr. Charles C. Brown, and temporarily by Messrs. H. C. Gould and W. Voigt.

The following is a summary of work done in the field between May 1 and November 23, 1879:

Number of stations occupied	16
Number of horizontal angles measured	105
Number of vertical angles measured	61
Number of topographical sketches of localities of stations made	13
Number of land survey corners located	23

Very respectfully,

R. S. WOODWARD,
Assistant Engineer.

General C. B. COMSTOCK,
Superintendent U. S. Lake Survey.

5.—REPORT OF MR. J. H. DARLING, ASSISTANT ENGINEER.

DETROIT, *June* 8, 1880.

SIR: I have to make the following report of work done during the year ending May 1, 1880:

From May 1, 1879, to December 5, 1879, I was engaged in measuring angles on the primary systems of triangulation extending between Lakes Erie and Michigan, and south from Lake Michigan. The instrument used was Troughton & Simms' 14-inch theodolite, L. S. No. 4, which gave good results as is usual with this instrument. My party consisted of C. M. Lightner, recorder, and Peter Neff, attendant. Mr. Lightner's services were very valuable. In addition to the measurement of primary angles, zenith distances were measured to all stations visible for the purpose of trigonometrical leveling; connections were made with many churches and other public buildings, and one or more section corners of the United States land survey were located in the vicinity of each station. Topographical sketches of the surroundings of stations were also made on a scale of $\frac{1}{5000}$, embracing full details for a distance of at least 1,500 feet in every direction from the station. The following is a summary of the season's field work:

ON MICHIGAN TRIANGULATION (MAY 1 TO JULY 10).

Number of stations occupied	4
Number of primary angles measured	28
Number of vertical angles measured	19

ON ILLINOIS TRIANGULATION (JULY 11 to DECEMBER 5).

Number of stations occupied	10
Number of primary angles measured	66
Number of vertical angles measured	47

After completion of field work I returned to the office in Detroit and tabulated results of measurements, and have since been engaged on current computations.

Very respectfully,

J. H. DARLING,
Assistant Engineer.

General C. B. COMSTOCK,
Superintendent United States Lake Survey.

APPENDIX No. 5.

REPORT ON COMPARISONS OF THERMOMETERS AND DETERMINATION OF CORRECTIONS TO REDUCE THERMOMETER READINGS TO ABSOLUTE TEMPERATURES, BY MR. THOMAS RUSSELL, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich., April 14, 1880.

GENERAL: I have the honor to make the following report on the corrections of thermometers used on the measuring tubes of the Repsold base apparatus and the standard bars and yards.

In the autumn of 1879 thermometer Casella 21472 was sent to Prof. H. A. Rowland, of Johns Hopkins University, Baltimore, to be compared with standards there, the corrections of which had been previously determined by comparison with an air-thermometer. The standards used at Baltimore to compare with 21472 were Baudin 6163 and 6165. The corrections of 21472 given by Prof. H. A. Rowland are the reductions to absolute temperature, absolute temperature being the corrected indication of the air-thermometer. This correction reduces the air-thermometer temperature 0°.006 C. at 30°C. and a less amount at lower temperatures.

In order to get the corrections of the various other thermometers to reduce to absolute temperature, they were compared with 21472 in water. These comparisons were made vertical, but as the thermometers when in use are mostly always horizontal, it is necessary to know their corrections in this position. The corrections of 21472 are given by Professor Rowland for both horizontal and vertical positions. As, however, the vertical comparisons are more numerous and were moreover made with two standards, the results from the vertical comparisons are adopted.

To determine the differences in the readings of the thermometers in the two positions, they were all tested separately at Detroit. The thermometer to be tested was put horizontally in water and read, then as quickly as possible brought vertical and read again. In both positions the bulb was kept as nearly as practicable in the same part of the vessel. Usually, for each thermometer ten such sets of readings were made at the various temperatures tried, and the mean of the differences taken as the difference at that point. Table I contains the mean differences derived in this way. The numbers given are the horizontal minus the vertical readings, the thermometers in every case when horizontal reading greater than when vertical.

TABLE I.—*Observed differences in horizontal and vertical readings, Detroit, March* 16–30. 1880; 6131 *at boiling point, March* 26, *April* 14, 1879.

[Freezing-point determinations of all except 6131 made March 8–11 and March 23–26, 1875.]

Casella. 21472.		Casella. 21474.		Casella. 21475.	Casella. 21476.	T. & S., 230.		Baudin, 6131.	
°	°	°	°	°	°	°	°	°	°
32 F.	0.04 F.	32 F.	0.04 F.	0.05 F.	0.03 F.	32 F.	0.08 F.	0.0 C.	0.00 C.
45	0.04	56	0.04	0.06	0.06	56	....	8.3	0.09
62	0.05	74	0.065	0.08	0.07	74	....	18.4	0.02
75	0.08	94	0.09	0.08	0.10	....	....	33.6	0.06
90	0.08	....	....	....	....	90	0.16	100	0.16

The difference in the horizontal and vertical readings of 21472 was also determined by Professor Rowland. He observed the difference at temperatures ranging from 72° F. to 101° F. The manner of observing, as described in his letter of March 27, 1880, was to place the thermometer in a closed vessel filled with water, the stem projecting through a cork; the thermometer was read vertical with the bulb down; the vessel was then inverted so that the thermometer was vertical with the bulb up and read again. Half the difference between two such readings was taken as the difference between the vertical and horizontal reading. As Professor Rowland's readings are at such high temperatures, and his observations being numerous, his results for 21472 are adopted and they are the ones given in Table II for that thermometer. For the other Casella thermometers and Troughton and Simms 230, the observations in Table I were combined separately for each thermometer. The depression was assumed to vary with the length of the column.

A depression per degree was computed from each observed difference by dividing the differences of depression observed at 32°, and the points above by the number of degrees above 32°. The results from the various temperatures were weighted directly as the squares of the lengths of the columns above 32°. With the depressions per degree obtained in this way, the differences for each thermometer at various points were com-

puted, and are given in Table II. In the computation of the differences for Baudin 6131, only the observed difference at boiling point was used. The Geissler thermometers, 1, 2, 3, 4, were observed horizontally and vertically at freezing point, and at a temperature of 80° F. The greatest difference found was 0°.05 for Geissler 3 at 80°. The differences are so small that they might all be owing to errors of observation. No account is therefore taken of them, and the Geissler thermometers are considered to read the same in both positions.

TABLE II.—*Differences in horizontal and vertical readings computed from observed differences.*

[Differences at 32° are observed; 21472 is from Rowland's comparisons; the rest from lake survey comparisons.]

Temperature.	21472.	21474.	21475.	21476.	230.	Temperature.	6131.
	°	°	°	°	°	°	°
32° F.	0.03 F.	0.04 F.	0.05 F.	0.03 F.	0.08 F.	0 C.	0.000 C.
42	0.04	0.05	0.06	0.04	0.09	5	0.009
52	0.06	0.05	0.06	0.05	0.11	10	0.018
62	0.07	0.06	0.07	0.06	0.12	15	0.027
72	0.09	0.07	0.07	0.07	0.14	20	0.036
82	0.10	0.07	0.08	0.08	0.15	25	0.045
92	0.115	0.08	0.08	0.095	0.16	30	0.054
....	....	....	....	....	....	35	0.063

The differences given in Table II are to be used in changing corrections for a vertical position to a horizontal, or the reverse, horizontal to vertical.

Experiments were made at Detroit, March 18, 1880, to determine whether when the Casella thermometers are horizontal and the temperature falling there is any lagging of the column of mercury, causing their readings to be too great. To test this, two of the thermometers, 21474 and 21475, were tried. The thermometer to be tried was placed horizontally in water; after the temperature had fallen several degrees it was read, then made vertical and read again. The various experiments made showed no greater difference than 0°.1 F., or about the same as in the other horizontal and vertical observations. Another experiment made, with a Cassella thermometer, was to let the mercury run from the bulb until the chamber at the top of the thermometer was nearly full; then, when the thermometer was made horizontal and left at rest, even though the bulb was slightly higher than the mercury in the tube and chamber, the mercury was gradually forced from the chamber along the tube, filling and finally leaving no trace of a bubble in the bulb. It was also found that after the Casellas and 6131 had been kept vertical for a week, at a mean temperature of 62°, it had no effect on their freezing points.

The standards, Baudin 6163 and 6165, with which 21472 was compared, are graduated on an arbitrary scale to millimeters. The freezing point of 6163 is at about the reading 59 mm, and that of 6165 at about 35 mm. A description of these thermometers is given in Professor Rowland's paper on the Mechanical Equivalent of Heat, reprinted from the proceedings of the American Academy of Arts and Sciences. Tables XVIII and XIX of that publication give the temperatures corresponding to the readings of the thermometers for every ten millimeters. In a letter of March 27, 1880, Professor Rowland states that the temperatures given in Tables XVIII and XIX have to be increased for the various points of the scale by the differences between the first and second columns of Table LIII of the same paper. This, he explains, arises from adopting a better value for the "*m*" in the formula of reduction to the air-thermometer.

Table III contains the observations made by Professor Rowland from which are derived the corrections of 21472 vertical, to reduce its readings to absolute temperature. On November 4, each reading is the mean of four observations; on the other days, of eight.

TABLE III.—*Readings of thermometers in water. Vertical—Rowland.*

November 4, 1879.			November 6, 1879.			November 7, 1879.			November 10 and 11, 1879.		
6163.	6165.	21472.	6163.	6165.	21472.	6163.	6165.	21472.	6163.	6165.	21472.
mm.	*mm.*	°.	*mm.*	*mm.*	°.	*mm.*	*mm.*	°.	*mm.*	*mm.*	°.
....	....	....	*58.8	*35.7	*32.07	*58.7	*35.6	*32.06	*58.6	*35.5	*32.04
124.2	117.8	45.33	125.4	119.5	45.56	124.7	118.4	45.44	122.7	115.9	45.00
208.4	227.7	62.25	208.4	227.7	62.29	208.8	228.2	62.37	206.4	225.3	61.88
274.0	314.2	75.29	271.7	311.0	74.88	275.6	316.5	75.67	271.3	310.7	74.80
349.0	417.7	90.27	349.7	418.9	90.42	349.1	417.8	90.27	347.8	416.4	90.02

*These readings in melting ice.

Table IV shows the corrections to be applied to 21472 to reduce to absolute temperature as derived from each day's observations, and from each of the thermometers 6163, 6165.

TABLE IV.—*Total corrections of* 21472 *to reduce to absolute temperature. Vertical.*

[From comparisons with 6163.]

Date.	32° F.	45° F.	62° F.	75° F.	90° F.
1879.	°	°	°	°	°
November 4	....	— 0.11	— 0.06	— 0.05	— 0.08
November 6	— 0.07	— 0.10	— 0.10	— 0.09	— 0.10
November 7	— 0.06	— 0.10	— 0.08	— 0.09	— 0.06
November 10 and 11	— 0.04	— 0.04	— 0.05	— 0.05	— 0.04
Means	— 0.06	— 0.09	— 0.07	— 0.07	— 0.07

[From comparisons with 6165.]

Date.	32° F.	45° F.	62° F.	75° F.	90° F.
November 4	....	— 0.12	— 0.09	— 0.05	— 0.06
November 6	....	— 0.08	— 0.13	— 0.11	— 0.04
November 7	....	— 0.12	— 0.12	— 0.08	— 0.03
November 10 and 11	....	— 0.06	— 0.06	— 0.05	+ 0.04
Means	....	— 0.09	— 0.10	— 0.07	— 0.02

By combining the results of the two thermometers, giving 6163 double weight, Professor Rowland derived the system of corrections to 21472 given in Table V. These are the adopted corrections to reduce to absolute temperature, from which, by means of comparisons made in water, the corrections of the other thermometers are derived after making a reduction for the change of freezing-point.

TABLE V.—*Adopted total corrections of* 21472, *November*, 1879, *to reduce to absolute temperature. Vertical.*

Temperature.	Correction.
°	°
32 F.	−0.06 F.
45	−0.08
62	−0.08
75	−0.07
90	−0.06

In the discussion of thermometer corrections and their use, it will be found convenient to separate the total corrections into parts. Denote by *a* the correction of a thermometer at freezing-point, and by *b* the difference between the total correction at any other point and that at freezing-point. Then *a* will be a quantity that varies with the time as the reading of a thermometer in melting ice becomes greater from year to year, and *b* will be constant as regards the time, but vary for different parts of the thermometer scale. Table VI gives accordingly the *b*-corrections of 21472 to reduce to absolute temperature, being the total corrections in Table V diminished by the *a*-correction or correction at freezing-point (— 0°.06).

TABLE VI.—*b-correction of* 21472 *to reduce to absolute temperature. Vertical.*

Temperature.	*b*-correction.
°	°
32	0.00
45	−0.02
62	−0.02
75	−0.01
90	0.00

Though the results of Professor Rowland's horizontal comparisons of 21472 are not made use of, it will be of interest to see how they agree with the results of his vertical comparisons after the vertical results are reduced to the horizontal by the differences between horizontal and vertical readings for 21472 given in Table II. As the thermometer reads higher in a horizontal than in a vertical position, and the *b*-corrections in both positions are the corrections at the various points when the correction at freezing-point is zero, therefore the *b*-corrections vertical are to be changed into *b*-corrections horizontal by increasing the vertical *b*-corrections at the various points by the differences between the excess of the horizontal over the vertical readings at freezing-point and the points for which the horizontal corrections are required. Thus the excess of the horizontal readings from Table II at freezing-point is 0°.03, and at 45°, 62°, 75°, and 90°, respectively, 0°.05, 0°.07, 0°.09, and 0°.11. The vertical *b*-corrections will therefore have to be increased by 0°.02, 0°.04, 0°.06, and 0°.08, respectively, at the points 45°, 62°, 75°, and 90°, to give the horizontal *b*-corrections.

The horizontal comparisons of 21472 were made with 6163 vertical. The stems of both thermometers projected from the vessel containing the water in which they were compared. The temperature of the projecting part was known by means of a thermometer lashed to the stem. Proper corrections were made to the indications of both thermometers when the temperature of the stems differed from that of the water. The greatest correction for this difference of temperature in any case was 0°.07 F. In deriving the horizontal *b*-corrections from the total corrections as given by Professor Rowland in his letter of March 27, 1880, the *a*-correction made use of was the mean of that given by Professor Rowland's readings in melting ice, vertical, March 16 and 18, and those made at Detroit March 27, vertical, the mean being increased by 0°.03 to reduce it to a horizontal position. This mean was —0°.08, so that the *a*-correction used was (—0°.08 — 0°.03) = — 0°.11. Table VII contains the horizontal *b*-corrections derived from the vertical comparisons of November, 1879, and the horizontal comparisons of March 16 and 18, 1880.

TABLE VII.—*b-corrections of* 21472 *to reduce to absolute temperature. Horizontal.*

Kind of comparison.	Date.	Temperatures and corrections.				
		°	°	°	°	°
Horizontal comparison with Baudin 6163......	Mar. 16, 1880	32.00 0.00	53.2 —0.08	63.3 —0.07	75.4 —0.09	90.4 —0.06
Horizontal comparison with Baudin 6163......	Mar. 18, 1880	32.00 0.00	52.2 —0.08	62.4 —0.08	75.6 —0.07	91.1 —0.02
Mean of two days..........................		0.00	—0.08	—0.08	—0.08	—0.04
Vertical comparison with 6163 and 6165 reduced to horizontal......................	Nov. 4, 6, 10, 11, 1879.	32.00 0.00	45.00 —0.04	62.00 —0.06	75.00 —0.07	90.00 —0.08

To obtain the corrections of 21474, 21475, 21476, 230, and 6131 to reduce to absolute temperature, comparisons were made with them and 21472 March 29 to April 1, 1880, at Detroit. Comparisons were also made with 21472 and Geisslers 1, 2, 3, and 4. The comparisons were made vertical in water. The readings of the thermometers were made by a telescope with a micrometer, except the Geisslers and occasionally 6131, the readings of which were estimated by the telescope. The comparisons were divided into two parts, 21472 with the Geisslers, and 21472 with all the others. The method of observation was first to read 21472, then the others under comparison at that time, and last, 21472 again. The mean of the two readings of 21472 is the quantity taken to compare with the other readings of thermometers. The differences in the first and last readings of 21472 were usually not greater than 0°.02; the greatest difference was in one instance 0°.04. A set of readings usually took about 4 minutes. The temperature of the air in the room during comparison was kept the same as that of the water. Six sets of readings were made at each temperature compared, which took about one hour. The greatest ranges in the temperature of the water during comparisons were at 45°, 0°.02; at 62°, 0°.30; at 75°, 0°.05, and at 90°, 0°.08. The thermometers when in the water were close together, 21472 being in the center of the group and the distance between the outside thermometers not being greater than 6 inches. The bulbs of the thermometers were nearly in the same level.

The water was kept continually stirred while the thermometers were not being read. There was about 1 inch of water between the thermometers and the glass side of the vessel through which they were read. Tables VIII and IX contain the readings of the thermometers vertical in water, each result being the mean of six observations, except those for the Geissler at 75° and 90°, which are the means of four, and the readings of 21472, which are the means of twelve at most temperatures, and of only eight at the 75° and 90° comparisons with the Geisslers.

TABLE VIII.—*Mean thermometer readings in water. Vertical.*

Date.	Casella.				T. & S.	Baudin.
	21472.	21474.	21475.	21476.	230.	6131.
1880.	°	°	°	°	°	°
March 16, 18, 27, 31	*32.08 F.	*32.00 F.	*32.00 F.	*32.04 F.	*32.48 F.	*0.356 C.
March 29	45.31	45.21	45.25	45.27	45.91	7.048
March 29	62.48	62.44	62.45	62.46	62.80	17.100
March 30	74.66	74.59	74.61	74.61	74.79	23.780
March 30	90.37	90.31	90.36	90.37	90.44	32.450

*Readings in melting ice, 21472 mean of Professor Rowland's, March 16, 18, vertical, and Detroit March 27, vertical; other Casellas, March 27, vertical; 230, March 31, vertical; 6131, March 27, 31, vertical.

TABLE IX.—*Mean thermometer readings in water. Vertical.*

Date.	Casella.	Geisslers.			
	21472.	1.	2.	3.	4.
1880.	°	°	°	°	°
March 20	*32.08 F.	*32.48 F.	*32.40 F.	*31.46 F.	*32.32 F.
March 29	45.36	45.80	45.60	44.72	45.60
March 29	62.18	62.86	62.49	61.66	62.53
April 1	75.27	76.08	75.70	74.77	75.58
March 30	90.40	91.34	90.90	90.00	90.80

* Readings in melting ice, 21472 same as in Table VIII. The Geisslers, March 20.

By means of the *b*-corrections of 21472 given in Table VI, and the *a*-correction, the total correction of 21472 can be obtained by adding to each *b*-correction the *a*-correction, which is—0°.08, at the time of the comparisons. Applying the total corrections obtained in this way to the readings of 21472, and taking the differences between these corrected readings and the other thermometer readings, there will be obtained the total corrections of the other thermometers. Table X contains the total corrections of the thermometers derived in this way. Table XI contains the *b*-corrections of the same thermometers, and is derived by subtracting from the total corrections the correction of each thermometer at freezing point, or its *a*-correction.

TABLE X.—*Total corrections of thermometers, March, 1880, to reduce to absolute temperature. Vertical.*

Temperature.	Casellas.				Geisslers.			
	21472.	21474.	21475.	21476.	1.	2.	3.	4.
°	°	°	°	°	°	°	°	°
32 F.	—0.08 F.	0.00 F.	0.00 F.	—0.04 F.	—0.48 F.	—0.40 F.	+0.54 F.	—0.32 F.
45	—0.10	0.00	—0.04	—0.06	—0.54	—0.34	+0.54	—0.34
62	—0.10	—0.06	—0.07	—0.08	—0.78	—0.41	+0.42	—0.45
75	—0.09	—0.02	—0.04	—0.04	—0.90	—0.52	+0.41	—0.40
90	—0.08	—0.02	—0.07	—0.08	—1.02	—0.58	+0.315	—0.48

TABLE XI.—*b-corrections of thermometer to reduce to absolute temperature. Vertical.*

Temperature.	Casellas.				Geisslers.			
	21472.	21474.	21475.	21476.	1.	2.	3.	4.
°	°	°	°	°	°	°	°	°
32 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.
45	—0.02	0.00	—0.04	—0.02	—0.06	+0.06	0.00	—0.02
62	—0.02	—0.06	—0.07	—0.04	—0.30	—0.01	—0.12	—0.13
75	—0.01	—0.02	—0.04	—0.00	—0.42	—0.12	—0.13	—0.08
90	0.00	—0.02	—0.07	—0.04	—0.54	—0.18	—0.23	—0.16

Table XII contains the *b*-corrections of Baudin 6131, derived in the same way.

Table XII.—*b-corrections of Baudin* 6131, *to reduce to absolute temperature. Vertical.*

Thermometer-reading.	*b*-Corrections.
°	°
0.36 C	0.000 C
7.65	+0.047
17.10	+0.134
23.78	+0.226
32.45	+0.289

From the vertical *b*-corrections of Tables XI and XII, the horizontal *b*-corrections are derived by applying to the vertical *b*-corrections of each thermometer the differences of the quantities given in Table II for the 32° point and the points for which the horizontal *b*-corrections are required. As these differences when the thermometers are horizontal increase with the temperature, the effect of this reduction to the horizontal position will be a gradual numerical increase of the minus-corrections of the Casellas and a numerical decrease of the plus-corrections of 6131.

The corrections of the Geisslers undergo no alterations, as the readings vertical and horizontal are the same. Tables XIII and XIV contain the horizontal *b*-corrections derived in this way.

Table XIII has also the *b*-corrections, horizontal, of 21473, derived from horizontal comparisons with 21472, made in January, 1879, taking the horizontal *b*-corrections of 21472 as given in Table XIII. The corrections of 21473 as derived in this way are given, because the thermometer was broken in the summer of 1879, while being used in the comparing-room of the base-apparatus.

Table XIII.—*b corrections of thermometers to reduce to absolute temperature. Horizontal.*

Temperature.	Casellas.					Geisslers.			
	21472.	21473.	21474.	21475.	21476.	1.	2.	3.	4.
°	°	°	°	°	°	°	°	°	°
32 F	0.00 F	0.00 F	0.00 F	0.00 F	0.00 F	0.00 F	0.00 F	0.00 F	0.00 F
45	−0.04	−0.04	−0.01	−0.05	−0.03	−0.06	+0.06	0.00	−0.02
62	−0.06	−0.01	−0.08	−0.09	−0.07	−0.30	−0.01	−0.12	−0.13
75	−0.07	−0.05	−0.05	−0.06	−0.04	−0.42	−0.12	−0.13	−0.08
90	−0.08	−0.08	−0.06	−0.10	−0.11	−0.54	−0.18	−0.22	−0.16

Table XIV.—*b-corrections of Baudin* 6131, *to reduce to absolute temperature. Horizontal.*

Thermometer-readings.	*b*-Corrections.
°	°
0.36 C	0.000 C
7.66	+0.033
17.13	+0.103
23.82	+0.183
32.51	+0.231

The thermometer Troughton and Simms No. 230 was calibrated, but the bore was found to be so poor that the work was not carried to any great extent. The calibration correction at 120° F. is +1°.1 F. As, however, important work has been done with this thermometer, which renders a knowledge of its corrections necessary, it was decided, in addition to the corrections derived from the comparisons given in Table VIII, to get the corrections at as many other points as possible from all the comparisons ever made with it and any of the Casellas, or with it and any other good thermometer that had been compared with the Casellas, as the Baudin 6131, or A_1, A_2, A_3, A_4. That some idea of the calibration corrections may be formed, the observed lengths of three columns of mercury are given in Table XV as measured in different parts of the bore.

TABLE XV.—*Calibration of T. and S. No. 230—measured lengths of columns.*

90° COLUMN.

Space.	First observation.	Second observation.	Third observation.	Fourth observation.	Means.
	°	°	°	°	°
[32-119]	86.07	86.07	....	....	**86.07**
[122-211]	88.15	88.20	....	....	**88.18**
Mean	....	....	....	....	**87.12**

60° COLUMN.

	°	°	°	°	°
[32-92]	60.45	60.47	60.45	60.45	**60.46**
[92-152]	60.35	60.43	60.39	60.36	**60.38**
[152-212]	62.01	62.01	62.00	62.01	**62.01**
Mean	....	....	....	....	**60.95**

30° COLUMN.

	°	°	°	°	°
[32-62]	30.23	30.21	....	....	**30.22**
[62-92]	30.07	30.06	....	....	**30.06**
[92-122]	29.78	29.77	....	....	**29.78**
[122-152]	30.43	30.44	....	....	**30.44**
[152-182]	30.76	30.77	....	....	**30.76**
[182-212]	31.11	31.07	....	....	**31.09**
Mean	....	....	....	....	**30.39**

With these observations the calibration corrections given in **Table XVI** are co puted according to the method known as Hällström's, **which is the same as that us** by Lieutenant-Colonel Clarke in his work on **Standards of Length.**

TABLE XVI.—*Calibration corrections of T. and S. No. 230.*

Temperature.	90° column.	60° column.	30° column.
°	°	°	°
32	0.0	0.0	**0.0**
62	....	....	**+0.17**
92	....	+0.49	**+0.50**
122	+1.05	....	**+1.11**
152	....	+1.06	**+1.06**
182	....	....	**+0.69**
212	0.0	0.0	**0.0**

Table XVII contains all the observations made use of in the **determination of t** corrections of 230, except those already given in **Table VIII.**

TABLE XVII.

Date.	Number of observations and position of thermometer.	Thermometer-readings.	Thermometer-readings.
	Horizontal.	Casella 21472.	T. & S. 230.
		°	°
December 16, 1875		*32.01 F.	*32.33 F.
January 17, 1876	20	59.25	59.50
	Horizontal.	Clark yard thermometers A_1, A_2, A_3, A_4.	T. & S. 230.
		°	°
December 16, 22, 1875		*32.40 F.	*32.33 F.
January 10, 1876	8	58.84	58.86
January 12, 1876	16	59.95	59.95
January 8, 1876	2	64.92	64.82
	Vertical.	Casella 21472.	T. & S. 230.
		°	°
January 2, 3, April 2, 1877		*32.00 F.	*32.31 F.
March 24, April 3, 1877	20	40.49	40.87
March 23, 31, 1877	20	50.16	50.54
March 26, 30, 1877	20	60.22	60.44
March 27, 29, 1877	20	70.22	70.30
March 28, 1877	10	79.84	79.80
	Horizontal.	Baudin 6131.	T. & S. 230.
		°	°
February 13, 14, 1880		*0.386 C.	*32.38 F.
February 13, 14, 1880	4	4.632	40.14
February 13, 14, 1880	4	5.772	42.27
February 13, 14, 1880	4	6.792	44.11
February 13, 14, 1880	4	7.998	46.32
February 13, 14, 1880	4	9.034	48.13
February 13, 14, 1880	4	10.044	50.00

* These readings in melting snow or ice.

By means of these observations and those in Table VIII, the *b*-corrections of 230 are derived, to reduce to absolute temperature. Where the readings were made vertical, the horizontal corrections are deduced with values given in Table II. Where comparisons with A_1, A_2, A_3, A_4 were made the horizontal *b*-corrections of A_1, A_2, A_3, A_4, for absolute temperature, were used, which are derived from the comparisons of 21472 with them, made January and May, 1879. Table XVIII contains the *b*-corrections of 230 to reduce to absolute temperature. The corrections of 6131 made use of are in Table XIV.

TABLE XVIII.—*b-corrections of Troughton and Simms 230, to reduce to absolute temperature. Horizontal.*

Temp.	Correction.	Date.	Position and thermometer.
°	°		
32 F.	0.00 F.	....	....
39.7	−0.08	Feb., 1880	Hor., 6131.
40.5	−0.09	Mar., 1877	Vert., 21472.
41.7	−0.15	Feb., 1880	Hor., 6131.
43.6	−0.15	Feb., 1880	Hor., 6131.
45.3	−0.23	Mar., 1880	Vert., 21472.
45.8	−0.17	Feb., 1880	Hor., 6131.
47.6	−0.11	Feb., 1880	Hor., 6131.
49.5	−0.14	Feb., 1880	Hor., 6131.
50.2	−0.12	Mar., 1877	Vert., 21472.
58.8	−0.01	Jan., 1876	Hor., A_1, A_2, A_3, A_4.
59.3	+0.01	Jan., 1876	Hor., 21472.
60.0	+0.02	Jan., 1876	Hor., A_1, A_2, A_3, A_4.
60.4	+0.03	Mar., 1877	Vert., 21472.
62.5	+0.02	Mar., 1880	Vert., 21472.
64.9	+0.13	Jan., 1876	Hor., A_1, A_2, A_3, A_4.
70.2	+0.17	Mar., 1877	Vert., 21472.
74.7	+0.21	Mar., 1880	Vert., 21472.
79.8	+0.28	Mar., 1877	Vert., 21472.
90.4	+0.25	Mar., 1880	Vert., 21472.

Table XIX contains the corrections of 230, taken from a curve constructed with the values given in Table XVII, the temperature being the abscissas and the corrections the ordinates. Table XIX has also the *b*-corrections to reduce to absolute temperature of A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4. Those of A_1, A_2, A_3, A_4 are derived from the horizontal comparisons made with them and 21472, January and May, 1879. The corrections of B_1, B_2, B_3, B_4 are derived by applying to the *b*-corrections of A_1, A_2, A_3, A_4 given in Table XIX, the differences between the *b*-corrections of A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4 obtained from Lieutenant-Colonel Clarke's values of their total corrections given in the report for 1875, page 57. This method of deriving the corrections of the A_1, A_2, A_3, A_4 and then B_1, B_2, B_3, B_4 by the differences is adopted in preference to the method of getting the corrections of B_1, B_2, B_3, B_4 first from comparisons made with 21472 in May, 1879, and then the corrections of A_1, A_2, A_3, A_4 by differences, because there were two sets of comparisons of A_1, A_2, A_3, A_4 with 21472 and only one set with B_1, B_2, B_3, B_4. The greatest discrepancy in the two sets was 0°.02 F. If the *b*-corrections of B_1, B_2, B_3, B_4 had been derived from the horizontal comparisons with 21472 made May, 1879, instead of from the *b*-corrections of A_1, A_2, A_3, A_4 by means of Clarke's differences, the corrections at 52°, 55°, 57°, 62°, and 93° would have been less by the quantities 0°.05, 0°.04, 0°.01, 0°.06, 0°.03, respectively. These numbers represent the discrepancies arising from errors of observation between the two systems of comparisons of A_1, A_2, A_3, A_4 with B_1, B_2, B_3, B_4, as made by Lieutenant-Colonel Clarke in April, 1874, and at Detroit, in May, 1879. Clarke's results for the differences of A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4, are adopted, because he probably had the best facilities for making accurate readings of them.

TABLE XIX.—*b-corrections to reduce to absolute temperature. Horizontal.*

Temperature.	230.	Mean of A_1, A_2, A_3, A_4.	Mean of B_1, B_2, B_3, B_4.
°	°	°	°
32 F.	0.00F.	0.00	0.00
37	−0.05	0.00	
42	−0.15	+0.03	....
45	−0.23	....	....
47	−0.12	+0.04	....
52	−0.09	+0.05	+0.11
55	....	+0.07	+0.11
57	−0.03	+0.08	+0.09
62	+0.02	+0.09	+0.11
67	+0.15	+0.10	....
72	+0.19	+0.09	....
77	+0.25	+0.09	....
82	+0.28	+0.10	....
87	+0.27	+0.10	....
90.4	+0.25	+0.11	+0.12

Table XX contains the *a*-corrections, or the corrections derived from the readings in melting ice of the Casella thermometers. The *a*-correction of 21472, adopted for March, 1880, is the mean of the vertical determination at Detroit and that by Professor Rowland at Baltimore, both reduced to a horizontal position. The *a*-corrections of the other Casellas for March, 1880, are the vertical results corrected by the quantities in Table II, to reduce to the horizontal position.

TABLE XX.—*a-corrections of thermometers. Horizontal.*

Date.	21472.	21473.	21474.	21475.	21476.
	°	°	°	°	°
January, 1875, Kew Observatory, England	0.0 F.	+0.1 F.	+0.1 F.	+0.1 F.	+0.1 F.
March, 1875, Detroit	+0.06	+0.13	+0.14	+0.15	+0.13
December, 1875, Detroit	−0.01	+0.08	+0.06	+0.07	+0.08
September, 1876, Paris, Sainte Claire Deville	0.00	....	....	....	....
December, 1876, Detroit	−0.04	....	....	....	....
May, 1879, Detroit	−0.11	−0.05	−0.05	−0.05	−0.08
November, 1879, Baltimore, Professor Rowland	(−0.06−0.03)= −0.09	....	....	....	....
March 16, 18, 1880, Baltimore, Professor Rowland	(−0.09−0.03)= −0.12	....	....	....	....
March 27, 1880, Detroit	(−0.07−0.03)= −0.10	....	(−0.00−0.04)= −0.04	(0.00−0.05)= −0.05	(−0.04−0.03)= −0.07

Table XXI contains the *a*-corrections of the Geissler thermometers. In August, 1878, Geissler No. 1 was sent from the Sandusky base with the graduated scale loose. The scale was refastened. An interpolated value of the *a*-correction, therefore, between —0°.22 and —0°.55 would not be correct. As, however, the actual change of freezing-point of No. 1 between January, 1877, and January, 1879, was probably something near the same amount as for the others, a rate of change equal to the mean of the changes of the others might be used to derive its *a*-correction between January, 1877, and January, 1879.

TABLE XXI.—*a-corrections of Geissler thermometers. Horizontal.*

Date.	No. 1.	No. 2.	No. 3.	No. 4.
	°	°	°	°
January, 1877, Detroit	−0.22 F.	−0.13 F.	+0.66 F.	−0.18 F.
January, 1879, Detroit	*−0.55	−0.40	+0.50	−0.36
January, 1880, Detroit	−0.50	−0.41	+0.50	−0.28
March, 1880, Detroit	−0.50	−0.40	+0.51	−0.36
April 9, 1880, Detroit	....	†−0.08		
August 20, 1880, Detroit	−0.47	−0.10	....	....
December 8, 1880, Detroit	....	....	+0.48	−0.38

* See remarks above.
† Scale taken out to remove moisture; refastened in a different position, April 8, 1880

Table XXII contains the corrections at freezing-point of Troughton and Simms No. 230; Baudin, 6131, A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4. There is no difference in the horizontal and vertical readings of 6131 at freezing-point. The difference in the readings of 230 at freezing-point, horizontally and vertically, is 0°.08, as shown in Table II. To change any vertical correction at freezing-point into a horizontal freezing-point correction for the same time, that quantity must therefore be applied to the vertical *a*-correction. A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4, are always observed horizontally.

TABLE XXII.—*a-corrections of thermometers.*

Troughton and Simms 230.			Baudin 6131.		
Date.	Position.	*a*-correction.	Date.	Position.	*a*-correction.
		°			
December 19, 1873	Vertical	−0.06 F.	May 15, 1879	Horizontal	−0.252 C.
January 6, 1874	Vertical	−0.07	February 13, 14, 1880	Horizontal	−0.386
March 8, 1875	Horizontal	−0.32	March 20, 1880	Horizontal	−0.382
December 16, 1875	Horizontal	−0.33	March 27, 1880	Vertical	−0.376
April 2, 1877	Vertical	−0.31	March 27, 1880	Horizontal	−0.368
November 17, 1879	Horizontal	−0.36	March 31, 1880	Vertical	−0.356
February 14, 1880	Horizontal	−0.38			
March 31, 1880	Vertical	−0.48			
March 31, 1880	Horizontal	−0.52			
April 9, 1880	Vertical	−0.48			
April 9, 1880	Horizontal	−0.53			
November 20, 1880	Vertical	−0.44			

TABLE XXII—Continued.

Mean of A_1, A_2, A_3, A_4.		Mean of B_1, B_2, B_3, B_4.	
Date.	*a*-correction.	Date.	*a*-correction.
	°		°
April, May, 1874, Clarke	−0.29 F.	April, May, 1874, Clarke	−0.26 F.
March, 1875	−0.37	March, 1875	−0.34
December, 1875	−0.40	December, 1875	−0.38
May, 1879	−0.44	May, 1879	−0.42
March 31, 1880	−0.51		

Casella 21472 was compared when horizontal with 21474, 21475, and 21476, in January and May, 1879. It will be of interest to see how the corrections deduced from those comparisons agree with the corrections from the vertical comparisons of March, 1880.

Table XXIII contains the corrections as derived from both sets of comparisons.

TABLE XXIII.—*b-corrections of thermometers to reduce to absolute temperature. Horizontal.*

Temperature.	21474.		21475.		21476.	
	March, 1880.	May, 1879.	March, 1880.	January, 1879.	March, 1880.	May, 1879.
	°	°	°	°	°	°
32° F	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.
45° F	−0.01	−0.02	−0.05	−0.03	−0.03	−0.04
62° F	−0.08	−0.08	−0.09	−0.05	−0.07	−0.07
75° F	−0.05	−0.08	−0.06	−0.08	−0.04	−0.07
90° F	−0.06	−0.09	−0.10	−0.12	−0.11	−0.10

Table XXIV contains the *b*-corrections of the Geissler thermometers to reduce to absolute temperature deduced from the vertical comparisons with 21472, made March, 1877, and March, 1880.

TABLE XXIV.—*b-corrections of Geissler thermometers to reduce to absolute temperature. Vertical.*

Temperature.	No. 1.		No. 2.		No. 3.		No. 4.	
	March, 1880.	March, 1877.	March, 1880.	March, 1877.	March, 1880.	March, 1877.	March, 1880.	March, 1877.
	°	°	°	°	°	°	°	°
32° F	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.
45° F	−0.06	−0.18	+0.06	−0.03	0.00	−0.02	−0.02	−0.08
62° F	−0.30	−0.39	−0.01	−0.11	−0.12	−0.15	−0.13	−0.18
75° F	−0.42	−0.50	−0.12	−0.21	−0.13	−0.20	−0.08	−0.18
90° F	−0.54	....	−0.18	....	−0.23	....	−0.16	....

It will be observed from Table XXIV, that the corrections derived from the 1877 comparisons differ by about a tenth from the corrections given by the later comparisons, and always in the same direction, the old values giving a lower corrected temperature than the new. An explanation of this discrepancy may possibly be that the freezing-points of the Geissler thermometers, on which the 1877 comparisons depend, were determined three months before the comparisons were made, and in the interval a change might have taken place. The Geissler thermometers were new at that time, and a rise of the freezing-points of one-tenth in three months is quite probable. The corrections of the Geissler thermometers given in the printed report for 1879 were derived from the vertical comparisons of March, 1877, taking the corrections of 21472 as given by its comparisons with 6131. These comparisons of 21472 with 6131 were made in a horizontal position. The corrections for a vertical position were derived from the horizontal corrections by applying a constant 0°.04 for all points of the scale. This constant was the observed difference of the horizontal and vertical readings at freezing-point. On this account, the corrections of the Geisslers in the 1879 report are erroneous, by quantities varying from 0°.01 to 0°.05 in addition to the errors arising from the uncertainties of the freezing-points at the time the comparisons were made.

Table XXV contains the corrections of 21472 to reduce to absolute temperature and also the corrections as derived from comparisons with Baudin, 6131, taking 6131 as the standard. It will be seen that the difference in the two systems of corrections is about one tenth throughout the scale, so that the effect of using the corrections to reduce to absolute temperature will be to diminish uniformly all the previously corrected temperatures by about one-tenth. The last column in Table XXV represents the difference between the air-thermometer (absolute temperature) and mercurial thermometer.

TABLE XXV.—*b-corrections of* 21472. *Horizontal.*

Temp.	b-corrections to reduce to absolute temperature.	b-corrections as given by 6131.	Differences of air and mercurial thermometers.
°	°	°	°
32 F.	0.00 F.	0.00 F.	....
45	− 0.04	+ 0.04	− 0.08 F.
62	− 0.06	+ 0.02	− 0.08
75	− 0.07	0.00	− 0.07
90	− 0.08	− 0.02	− 0.06

The corrections of 6131 as a calibrated standand mercurial thermometer are given in the printed report for 1879. Interpolated values of the corrections from that table are shown side by side with the corrections to absolute temperature in Table XXVI.

The corrections to reduce to absolute temperature of 6131 are given in Table XIV.

TABLE XXVI.—*b-corrections of Baudin* 6131. *Horizontal.*

Thermometer readings.	b-corrections to reduce to absolute temperature.	b-corrections from calibration and scale-corrections.	Difference in the two systems.	Differences of air and mercurial thermometers.
°	°	°	°	°
0.36 C.	0.000 C.	0.000 C.	....	....
7.66	+ 0.033	+ 0.052	− 0.019 C.	− 0.03 F.
17.13	+ 0.103	+ 0.148	− 0.045	− 0.08
23.82	+ 0.183	+ 0.225	− 0.042	− 0.08
32.51	+ 0.231	+ 0.275	− 0.044	− 0.08

The last column of Table XXVI represents the difference between the air thermometer (absolute temperature) and mercurial thermometer.

The *b*-corrections of 21472, taking Baudin 6131 as the standard, may be obtained from the horizontal comparisons of May, 1879, and the vertical comparisons of March, 1880.

Table XXVII contains these two sets of corrections, taking Baudin 6131 as the calibrated mercurial standard.

TABLE XXVII.—*b-corrections of* 21472, *taking Baudin* 6131 *as mercurial standard in both sets. Horizontal.*

Temperature.	1st set, May, 1879.	2d set, March, 1880.
°	°	°
32 F.	0.00 F.	0.00 F.
45	+ 0.04	− 0.01
62	+ 0.02	+ 0.02
75	0.00	+ 0.01
90	− 0.02	0.00

The differences between the numbers in the last two columns are the descrepancies due to errors of observation in the two sets of comparisons. The greatest discrepancy is at 45° and is 0°.05.

For convenience in use and for reference there are given together the following tables of all the systems of corrections of the Casella and Yard thermometers that have been in use from time to time.

TABLE XXVIII.—*b-corrections of Casella thermometers, determined at Kew Observatory, England. Horizontal.*

[In use from March, 1875, to May, 1879.]

Temperature.	21472.	21473.	21474.	21475.	21476.
	°	°	°	°	°
32° F.	0.0 F.	0.0 F.	0.0 F.	0.0 F.	0.0 F.
35	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0
45	+0.1	0.0	0.0	0.0	0.0
50	+0.1	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	−0.1	0.0
90	0.0	0.0	0.0	−0.1	−0.1
95	0.0	0.0	0.0	0.0	0.0
100	0.0	0.0	0.0	0.0	0.0

TABLE XXIX.—*b-corrections of Casella thermometers, determined at Detroit, taking Baudin* 6131 *as the standard. Horizontal.*

[In use from May, 1879, to April, 1880.]

Temperature.	21472.	21473.	21474.	21475.	21476.
	°	°	°	°	°
32° F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.
37	+0.02	+0.02	+0.04	+0.04	+0.02
42	+0.04	+0.04	+0.07	+0.04	+0.04
47	+0.04	+0.04	+0.06	+0.02	+0.04
52	+0.04	+0.05	+0.04	+0.03	+0.03
57	+0.05	+0.07	+0.06	+0.04	+0.04
62	+0.02	+0.07	0.00	+0.03	+0.01
67	+0.02	+0.06	+0.01	+0.02	+0.03
72	+0.01	+0.04	+0.01	0.00	+0.02
77	−0.01	+0.01	−0.02	−0.02	−0.02
82	−0.03	−0.02	−0.04	−0.07	−0.06
87	−0.03	−0.03	−0.04	−0.07	−0.06
92	−0.01	−0.01	−0.02	−0.05	−0.03

TABLE XXX.—*b-corrections of Casella thermometers to reduce to absolute temperature. Horizontal.*

[In use during and after April, 1880.]

Temperature.	21472.	21473.	21474.	21475.	21476.
	°	°	°	°	°
32° F	0.00 F.	0.00 F.	0.00 F.	0.00 F.	0.00 F.
45	−0.04	−0.04	−0.01	−0.05	−0.03
62	−0.06	−0.01	−0.08	−0.09	−0.07
75	−0.07	−0.05	−0.05	−0.06	−0.04
90	−0.08	−0.08	−0.06	−0.10	−0.11

TABLE XXXI.—*b corrections of "Yard" thermometers, determined by Lieut. Col. A. R. Clarke.*

[In use from May, 1874, to May, 1879.]

Temperature.	Mean of A_1, A_2, A_3, A_4.	Mean of B_1, B_2, B_3, B_4.
	°	°
32° F	*0.00 F.	*0.00 F.
52	+0.07	+0.13
55	+0.11	+0.15
57	+0.12	+0.13
62	+0.07	+0.09
93	+0.12	+0.13

* Derived from Lieut. Col. A. R. Clarke's values of the total corrections, report of 1875, page 57.

TABLE XXXII.—*b-corrections of "Yard" thermometers, determined at Detroit, by taking Baudin 6131 as the standard.*

[In use from May, 1879, to April, 1880.]

Temperature.	Mean of A_1, A_2, A_3, A_4.	Mean of B_1, B_2, B_3, B_4.
	°	°
32° F	0.00 F.	0.00 F.
37	+0.04	+0.05
42	+0.10	+0.10
47	+0.12	+0.14
52	+0.14	+0.15
57	+0.18	+0.18
62	+0.17	+0.13
67	+0.18	+0.14
72	+0.17	+0.13
77	+0.15	+0.10
82	+0.14	+0.09
87	+0.15	+0.12
92	+0.19	+0.17

found not to be horizontal they will be made so by turning the telescope a small amount in the wyes. When the three wires have once been made horizontal, small screws which abut against projection of wye above elevating screw should be so adjusted that when they press against this projection the wires are horizontal. If the vertical thread is then inclined, as shown by the plumb-line attached to the rod, it must remain so.

To make the axis of the level parallel to the upper surface of the rings, it is necessary to make the vertical planes passing through them parallel (lateral adjustment), and to make them equally inclined to the horizon (vertical adjustment). To make the lateral adjustment raise the clips fastening the level on the telescope and revolve the level about the telescope a short distance each side of the vertical. If the bubble runs in opposite directions when on opposite sides of the vertical, the level is to be adjusted by means of the opposing horizontal screws at one end of the level-case, until such is not the case. To make the vertical adjustment, raise one of the clips and read the level in its direct position and also when it is reversed on the telescope. The difference between the differences of end-readings in each position is four times the error of adjustment, and is to be corrected by the opposing vertical screws at one end of the level-case. The error of adjustment must not be allowed to exceed two divisions of the level. Care must be taken that the telescope rings are free from dust while adjusting the level. After having made the vertical adjustment, it will be necessary to examine the lateral adjustment again, since making one of these adjustments affects the other.

To make the level and the vertical axes of revolution perpendicular to each other, loosen the small clamp-screw at one end of the horizontal bar fastened to the vertical axis, and by means of the elevating screw raise or lower that end of the upper horizontal bar until the telescope can be rotated 180° from any position and have the level-reading the same in both positions.

To adjust the level attached to the rod, set up the rod in its tripod in such a position that, when a plumb-line is attached to the small hook near the top of the rod, the point of the plumb-bob shall coincide with the point of a small cone attached to the rod near its foot. Now bring the level-bubble to the center by means of the three leveling screws. In making this adjustment the rod should not be exposed to the wind, as the plumb-line is influenced thereby. This adjustment will be made at least once each day.

Each time that the instrument is placed on a station its axis will first be made vertical by means of the leveling screws in such a manner that the telescope may be turned around the horizon without the bubble of the level running a great number of divisions.

The telescope is finally made horizontal by means of the elevating screw. The inclination at the moment of observing must not ordinarily exceed three divisions of the level and never five divisions. The instrument ought always to be sheltered from the sun by an umbrella. It is carried from station to station without being dismounted, but the level should be taken off and carried in the hand by the observer or recorder.

The small clamp-screw at end of horizontal bar and the large screw which fastens the instrument immovably to the tripod should both be turned tight before moving the instrument.

The rods must be placed on the plates which accompany them, and held in a vertical position as indicated by the spherical level attached.

It is advisable to always use the same rod with the same foot-plate. In placing the foot-plates great care should be taken that they are horizontal, on firm ground, and not liable to change. The upper surface of the ground, if not firm and level, should be removed with a spade.

The errors of adjustment will be determined at the beginning and at the end of each series of observations; that is to say, after having mounted the instrument, and before dismounting it, and in all cases at least once each day. If the instrument has been deranged by a jar, the corrections must be determined anew.

The error of collimation will be determined by two readings of the rod, at a distance of fifty meters, with the telescope in its normal position, and two when it is rotated 180° in the wyes. The difference between the means of the two readings after being corrected for inclination of level must not exceed 2.5^{mm} at that distance, and commonly should not exceed 1^{mm}.

The error of adjustment of the level (inclination) will be determined by reading the level four times when direct, and four times when reversed on the telescope, reversing it between each reading. The error of adjustment must not exceed two level divisions, and commonly should not exceed one. All the details of the determination of the errors of adjustment must be entered in the note-book in their proper place. It is always advisable to have errors of adjustment as small as possible, and necessary that they be well determined. The time of making these determinations will be recorded in the note book.

division of the level, tables will be constructed showing the corrections to be applied to a rod-reading for an observed inclination of the level and for a distance determined by interval between extreme threads.

Before using the level or determining its value, the fastening of the tube in its case should be examined. One end should be clamped down just tight enough to prevent the tube from moving easily, but not tight enough to strain the glass. The other end should be lightly clamped so that the tube may be free to expand and contract with temperature changes.

The cotton packing at the ends should not exert a lateral strain on the tube. All level tubes will be numbered and have their numbers marked upon them.

In order to determine the inequality of the telescope rings the instrument should be mounted on a stone pier or other firm support and carefully leveled.

The level should be carefully adjusted, and the instrument clamped to prevent its moving in azimuth.

Now, with the eye-piece of telescope above the elevating screw, note the reading of the bubble when level is placed on telescope both in a direct and reversed position. Now reverse the telescope in the wyes and read the level as before. Several sets of observations should be made. Let B, B′ = inclinations of telescope as denoted by means of level-readings with telescope direct and reversed. Then the inequality of rings, $p = \frac{B - B'}{4}$.

Sixteen determinations of the value of p of two instruments in use on the lake survey gave probable errors of $\pm 0''.046$ and $\pm 0''.041$. The inequality may be expressed in seconds of arc if desired, but for purposes of computation is better expressed in terms of level-divisions, as it can then be combined directly with the error of adjustment of level.

The centering of the object-glass will be examined. This may be done as follows: Draw out the eye-piece until the threads are no longer visible. Direct the telescope upon some well-defined object, and while looking at it rotate the telescope in its wyes. If the object remains steady, the object-glass is sufficiently well centered. Should the object appear unsteady, the fault can only be remedied by a maker. The objective should be firmly screwed into the telescope tube.

The value of the wire intervals will be determined as follows: Set up a rod at carefully-measured distances of 10^m 20^m 30^m .... 100^m from the instrument. Read the rod ten times at each distance. The rod may be altered in elevation, the level may be caused to change, and the telescope may be rotated 180° (inverted), in order to change the position of the threads on the rod. Taking the mean of the ten observed differences of readings of the extreme threads at each station occupied by the rod, a table will be constructed giving the distance in meters of the rod from the instrument, for any observed difference of reading between extreme threads. Unless the rods used have been previously compared with some known standard, they will be compared with each other and their relative lengths determined.

This may be done by establishing two fixed points, or two foot-plates, at equal distances from the instrument, and differing in elevation about 2.7^m. The distance should be about 10 meters.

Determine the difference of elevation of the points by reading each rod on each point. A comparison of the resulting differences of elevation will give relative lengths of meters on rods. Ten measurements with each rod will be made. The elevation of the instrument should be slightly changed between each set in order to eliminate errors in estimating the millimeters.

Each rod will be numbered and have its number marked on it. The rods should also be kept dry, and should be provided with canvas covers to protect them while being carried to and from work. The distance of the zero of graduation above the spherical steel spur on which the rod stands will be well determined. This may be done with a right-angled triangle and a rule. It may also be determined by means of another leveling rod, the graduation of which commences at the foot of the rod, by determining the height of the instrument above some fixed point and subtracting it from the reading of the rod to be determined.

The relative length of the rods must be known. Whenever a bench-mark is connected with in such a way that the rod is not placed directly on the bench-mark, this quantity (a) enters into the computation of difference of elevation.

Before commencing work at any time all adjustments will be carefully made. The telescope will be collimated by having a rod set up at a distance of fifty meters, and noting the position of the wires on the rod when the telescope is normal and when inverted, or rotated 180° about its axis. The collimation-error of the mean of the horizontal threads must not exceed 1.25^{mm} at a distance of 50^m.

The horizontality of the horizontal wires will be examined by moving the telescope in azimuth so that the rod shall appear to move through the field of the telescope. If the threads are horizontal the readings on the rod will be the same, the position of the level, which should be closely watched, remaining the same. If the threads are

[25] *December 30, 1878, 8 A. M.—L. L. Wheeler, observer; E. S. Davis, recorder.* [26]

[Kern level No. 1. Level tube No. 10.]

INCLINATION.

Level direct.		Level reversed.	
Eye.	Object.	Eye.	Object.
6.0	5.6	6.6	5.0
6.0	5.9	6.5	5.2
5.5	6.4	7.6	4.6
6.4	5.9	7.8	4.4
23.9	23.8	28.5	19.2
+0.1		+9.3	

$4 \times i = + 2.30$ *div.* for level direct.

COLLIMATION.

Thread reading.	Means.	Diff. of threads.	Level. Eye.	Level. Object.	Rod.	Remarks.
mm.	*mm.*	*mm.*	*div.*	*div.*		
		Telescope normal.				
812		255	5.9	6.4	3	
1,067	1,067.0	255	5.9	6.4		
1,322		510	11.8	12.8		
			−1.0			
		Telescope inverted.				
810		256	6.2	6.1	3	
1,066	1,065.3	254	6.1	6.1		
1,320		510	12.3	12.2		
			+0.1			
		Telescope normal.				
812		255	5.5	6.9	3	
1,067	1,067.0	255	5.5	6.9		
1,322		510	11.0	13.8		
			−2.8			
		Telescope inverted.				
810		256	6.1	6.1	3	
1,066	1,065.3	254	6.1	6.1		
1,320		510	12.2	12.2		
			0.0			

L. L. Wheeler, observer; E. S. Davis, recorder.

[Kern level No. 1. Level-tube No. 10.]

Back-sights.							Fore-sights.						
Thread readings.	Means.	Diff. of threads.	Level. Eye.	Level. Object.	Rod.	Remarks.	Thread readings.	Means.	Diff. of threads.	Level. Eye.	Level. Object.	Rod.	Remarks.
mm.	*mm.*	*mm.*	*div.*	*div.*			*mm.*	*mm.*	*mm.*	*div.*	*div.*		
2,393.5		151.5	5.9	6.7	2	B. S. on U. S. B. M. 6, at Trotter's Landing, Miss.	728.5		156.5	6.1	6.4	3	
2,545	2,545.2	152	5.9	6.7			885	885.0	156.5	6.3	6.2		
2,697		303.5	11.8	13.4			1,041.5		313	12.4	12.6		
			−2.6							−0.2			
1,130		379	6.0	6.9	3		851.5		376.5	6.1	6.8	2	
1,509	1,509.8	381.5	5.7	7.1			1,228	1,228.2	377	6.1	6.8		
1,890.5		760.5	11.7	14.0			1,605		753.5	12.2	13.6		
			−2.3							−1.4			
786		430	6.4	6.3	2		848		432	6.3	6.5	3	
1,216	1,217.3	434	6.5	6.3			1,280	1,281.0	435	6.3	6.5		
1,650		864	12.9	12.6			1,715		867	12.6	13.0		
			+0.3							−0.4			
936.5		406.5	6.5	6.3	3		985		408	6.4	6.4	2	
1,343	1,343.8	409	6.5	6.3		Cloudy.	1,393	1,394.0	411	6.4	6.4		
1,752		815.5	13.0	12.6			1,804		819	12.8	12.8		
			+0.4							0.0			
768		310.5	6.6	6.1	2		1,602		297	6.8	6.0	3	Foot-plate at crossing of road and levee. Line leaves levee here.
1,078.5	1,078.8	311.5	6.2	6.5			1,899	1,900.0	300	6.9	5.9		
1,390		622	12.8	12.6			2,199		597	13.7	11.9		
			+0.2							+1.8			
071		118	6.4	6.4	3		1,658		127	6.2	6.5	2	
189	189.3	119	6.5	6.3			1,785	1,785.2	127.5	6.1	6.5		
308		237	12.9	12.7			1,912.5		254.5	12.3	13.1		
			+0.2							−0.8			

The lengths of sights taken will depend upon the condition of the atmosphere, but the rod should always be near enough to be seen distinctly. It will be seldom that lengths of sights greater than 150 meters can be taken. The back-sight and fore-sight corresponding to any instrument station must not differ in length by more than ten meters; and the sum of the lengths of the back-sights and the sum of the lengths of the fore-sights between any two bench-marks should not differ more than twenty meters.

Whenever it is necessary that the line of levels should cross a river or other wide obstruction, a narrow place should be chosen. Firm points being set up on the two banks, levels in good adjustment are set up on posts about 10^m from each bench-mark, and both levels go through the same operations. *The error of adjustment is first accurately determined.* Call one of the levels A. A first reads on the bench-mark near it, once with the telescope normal and once with the telescope inverted, and then on the rod across the river, five times with telescope normal and five times with the telescope inverted. The error of adjustment of the level is again accurately determined. The rod across the river will need an extra vane. B performs the same operations simultaneously. A and B then change places, and repeat the observations at their new stations. The simultaneous levels eliminate refraction, the change of station eliminates curvature and small instrumental errors. Unless good results are obtained, the levels should be repeated. If but one level can be used, the operations will be performed in the same order, but the time occupied in crossing must be as small as possible. With a single Kern level this process has given for a river 815 meters wide five results the mean of which has a probable error of $\pm 0.5^{mm}$. (Ohio River at Cairo, Ill.)

Permanent bench-marks will be established once in three miles when it is possible. When permanent brick or stone buildings cannot be obtained on which to place these bench-marks, cut stone posts will be planted in positions least likely to be disturbed. These bench-marks will consist of a copper bolt 75^{mm} long and 10^{mm} in diameter, leaded into masonry, natural rock, or stone post. The end of the bolt should project about 1^{mm} from the lead. A small hole 1^{mm} in diameter drilled in end of bolt will be the point of reference. The letters U. S. B. M. should be cut near the bolt. In connecting with a bench-mark, if the bolt is vertical, the foot of the rod will be placed directly upon it. If the bolt is horizontal in the wall of a building or other structure, it may be best connected with as follows: Set up the instrument in such a position and at such an elevation that the small hole in the bolt may be bisected by the middle thread without displacing the level by more than five divisions, using the elevating screw for making this bisection. Since the instrument can be raised or lowered about two centimeters by means of the leveling screws, the instrument can be placed in such a position by two or three trials. Now bisect the bench-mark with the telescope normal and also inverted, noting the reading of the level. Read the rod on the plate with the telescope in both positions. It is necessary to eliminate collimation by inverting the telescope, since the collimation of the middle wire is not the same as that of the three wires. The quantity "*a*" (distance of zero above foot of rod) must be taken into account when a bench-mark is connected with in this manner.

The distance of the bench-mark from the instrument must be determined and recorded. Whenever work is stopped, at least two temporary bench-marks should be established. These will consist of large nails or spikes driven their entire length vertically into the base of trees, or in the tops of sound stumps. When not in the vicinity of trees or stumps, wooden posts may be firmly set in the ground with their tops flush with the surface, and the nails driven into them. When near the river temporary bench-marks should be set every two kilometers.

Every bench-mark will be fully described in a note-book kept for that purpose. Its position with reference to the most prominent objects near it should be given by distance and direction. Public buildings such as depots, court-houses, churches, &c., are the best positions for permanent bench-marks. In a village or town several permanent bench-marks should be established to secure some one against loss. If a railroad is crossed the elevation of the foot of the rail will be determined, and if leveling along a railroad, the elevation of the foot of the rail at the depots will be determined. If a town has any datum-plane its height will be determined.

In reducing the observations, the nearest tenth of a millimeter shall be retained. The distances will be taken out from the table to the nearest meter. In the following table is given a form for reducing the observations. For convenience of reference the columns are numbered at the bottom of pages. Columns 1, 2, 4, 7, 8, and 10 have been copied from the note-book. Columns 3 and 9 are obtained from 2 and 8 by means of a table of wire intervals. Columns 5 and 11 are obtained from columns 3 and 4 and 9 and 10 by means of the table of level corrections. Columns 6 and 12 are obtained by applying the corrections in 5 and 11 to the quantities in 1 and 7. The difference of the sums of corrected means is subject to four corrections, collimation, inclination, inequality of pivots, and correction due to length of meter on rod (rod equation). The first three corrections depend upon the difference between the sums of the lengths of the back-sights and fore-sights, and to determine this, the difference between the

sums of columns 2 and 8 should be taken. The correction for rod equation depends on the difference of elevation of the bench-marks. The rods used in the example given were Kern leveling rods 2 and 3, the value of one meter of which has been determined by comparison with the Lake Survey brass standard meter to be $999^{mm}.840$ and $999^{mm}.903$ respectively. (Office report 662.) The correction for these rods was taken to be $0^{mm}.13$ for each meter difference of elevation, and was opposite in sign to the difference of elevation. Having applied these four corrections, the difference of elevation is found. These corrections should be applied to the difference of elevation of any two bench-marks, as ref. point 13 and ref. point 13*a*. The limit of discrepancy between two lines of levels will be $5^{mm}\sqrt{\text{distance in kilometers}}$. For a distance between two bench-marks of 4 kilometers, the limit of discrepancy would be 10^{mm}. The line from U. S. B. M. 6 to ref. point 13 was releveled in the afternoon of the same day (December 30) in the opposite direction, with a discrepancy of $+0^{mm}.8$.

December 30, 1878.—L. L. Wheeler, computer.

Back-sights.						Fore-sights.						
Means of three wires.	Diff. of Ex. wires.	Dist.	Lev. div's.	Cor's.	Corrected means.	Means of three wires.	Diff. of Ex. wires.	Dist.	Lev. div's.	Cor's.	Corrected means.	
	Telescope normal.				Collimation.			Telescope inverted.				
mm.		*m.*		*mm.*	*mm.*	*mm.*		*m.*		*mm.*	*mm.*	
1,067.0	510	50	− 1.0	− 0.2	1,066.8	1,065.3	510	50	+ 0.1	0.0	1,065.3	
1,067.0	510	50	− 2.8	− 0.5	1,066.5	1,065.3	510	50	0.0	0.0	1,065.3	Collimation at 1m distance = $\frac{1,065.3-1066.65}{2 \times 50}$ = − 0.013 mm. for tel. direct.
					1,066.65						1,065.3	
2,545.2	303.5	30	− 2.6	0.3	2,544.9	885.0	313.5	31	− 0.2	0.0	885.0	
1,509.8	760.5	75	− 2.3	0.6	1,509.2	1,228.2	753.5	74	− 1.4	− 0.4	1,227.8	B. S. on U. S. B. M. 6.
1,217.3	864	85	+ 0.3	+ 0.1	1,217.4	1,281.0	867	85	− 0.4	− 0.1	1,280.8	
1,343.8	815	80	+ 0.4	+ 0.1	1,343.9	1,394.0	819	80	0.0	0.0	1,394.0	
1,078.8	622	61	+ 0.2	0.0	1,078.8	1,900.0	597	59	+ 1.8	+ 0.4	1,900.4	
189.3	237	23	+ 0.2	0.0	189.3	1,785.2	254.5	25	− 0.8	− 0.1	1,785.1	*dir.*
1,958.7	1,034	101	− 0.5	− 0.2	1,958.5	1,538.0	1,087	107	0.0	0.0	1,538.0	$4 \times i = + 2.30$ for level direct, 8.00 a. m.
1,595.0	787	77	+ 1.1	+ 0.3	1,595.3	1,810.0	761	75	+ 2.0	+ 0.6	1,810.6	$4 \times i = + 1.22$ for level direct, 12.20 p. m.
1,660.0	677	66	− 0.8	− 0.2	1,659.8	1,304.7	702	69	+ 1.7	+ 0.4	1,305.1	
1,503.7	592	58	− 0.2	0.0	1,503.7	1,918.7	573.5	56	+ 0.6	+ 0.1	1,918.8	
1,702.2	542	53	+ 1.4	+ 0.3	1,700.5	1,309.3	561	55	− 0.6	− 0.1	1,309.2	Mean = + 1.76.
1,409.7	610	60	− 0.6	− 0.1	1,409.6	1,260.5	581.5	57	+ 0.1	0.0	1,260.5	
1,091.7	652	64	+ 0.2	0.0	1,091.7	1,086.7	664	65	+ 0.9	+ 0.2	1,086.9	
1,046.2	630.5	62	− 0.6	− 0.1	1,046.1	1,175.7	620	61	− 2.0	− 0.4	1,175.3	Distance leveled = 3,192 meters.
1,562.3	684.5	67	+ 0.1	0.0	1,562.3	1,610.7	666	65	+ 0.3	+ 0.1	1,610.8	
1,679.7	920	90	+ 0.6	+ 0.2	1,679.9	1,475.0	915	90	− 0.2	− 0.1	1,474.9	
1,461.7	714	70	− 0.2	− 0.1	1,461.6	968.7	700	69	+ 1.0	+ 0.3	969.0	
997.0	813	80	+ 0.7	+ 0.2	997.2	1,385.3	855	84	− 0.3	− 0.1	1,385.2	(*Time occupied in leveling, including adjustments, 4h 20m.*)
1,379.7	704	69	+ 1.2	+ 0.3	1,380.0	1,561.2	721	71	− 0.2	− 0.1	1,561.1	
1,932.0	735	72	− 0.2	− 0.1	1,931.9	1,534.2	690.5	68	− 0.4	− 0.1	1,534.1	
1,255.7	912	89	+ 0.1	0.0	1,255.7	1,304.7	884	87	+ 0.4	+ 0.1	1,304.8	
1,343.7	732	72	+ 0.9	+ 0.2	1,343.9	2,075.7	790	77	+ 1.1	+ 0.3	2,076.0	
1,844.8	773.5	76	0.0	0.0	1,844.8	1,741.7	814	80	− 0.2	− 0.1	1,741.6	
1,422.0	110	11	+ 0.6	0.0	1,422.0	1,023.3	110	11	+ 3.7	+ 0.1	1,023.4	F. S. on Reference Point 13.
							111.5	11	− 1.3	− 0.0	720.3	F. S. on Reference Point 13*a*.
	16,225.0	1,591	....	....	+ 34,728.0	720.3						
							16,209.5	1,601	....	....	34,558.5	
											+ 34,728.0	

						Difference of corrected means					+ 169.5	
						Correction for collimation.....................					+ 0.1	
						Correction for inclination and pivots....... ..					0.0	
						Correction for rod-equation					0.0	
											+ 169.6	Reference Point 13 above U. S. B. M. 6.
							+1, 023.4	−720 3	=		+ 303.1	Reference Point 13a above Ref. Point 13.
1	2	3	4	5	6	7	8	9	10	11	12	13

APPENDIX No. 7.

WATER-LEVELS.

REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich., June 18, 1880.

GENERAL: I have the honor to submit the following report on water-levels of the northern and northwestern lakes, from June 1, 1879, to May 31, 1880.

Tri-daily observations have been made at Marquette, on Lake Superior; Milwaukee and Escanaba, on Lake Michigan; Port Austin, on Lake Huron; Detroit, on Detroit River; Cleveland and Erie, on Lake Erie; and Charlotte and Sacket's Harbor, on Lake Ontario. Daily observations have been made at Sault Ste. Marie, under direction of Maj. G. Weitzel, Corps of Engineers, in charge of the canal improvement, and furnished by him for publication. Observations were discontinued at Escanaba during the months of January, February, and March, on account of ice and snow.

Self-registering gauges have been running continuously at Marquette, Milwaukee, and Port Austin during the year.

The plane of reference for each lake remains unchanged and is the same as that given in Report of Chief of Engineers for 1876, Appendix H H.

For detailed description of methods employed in determining the planes of reference, description, and location of gauges and bench-marks, methods of reduction, &c., see Report of the Chief of Engineers for 1876, Part III, Appendix H H. See also accompanying plates with this report.

The differences of elevation between the permanent bench-marks and gauge-zeros have been determined recently. On Lakes Ontario and Erie, the determinations differ but slightly from those made in 1878. For Lakes Superior, Michigan, and Huron, the results have not yet been received.

The gauge-readings at all stations have been reduced to the planes of reference by the results of observations made in 1878, and published in the annual report for 1879, Appendix 9.

The accompanying table and graphical curves are continued from those given in the last annual report.

Respectfully submitted.

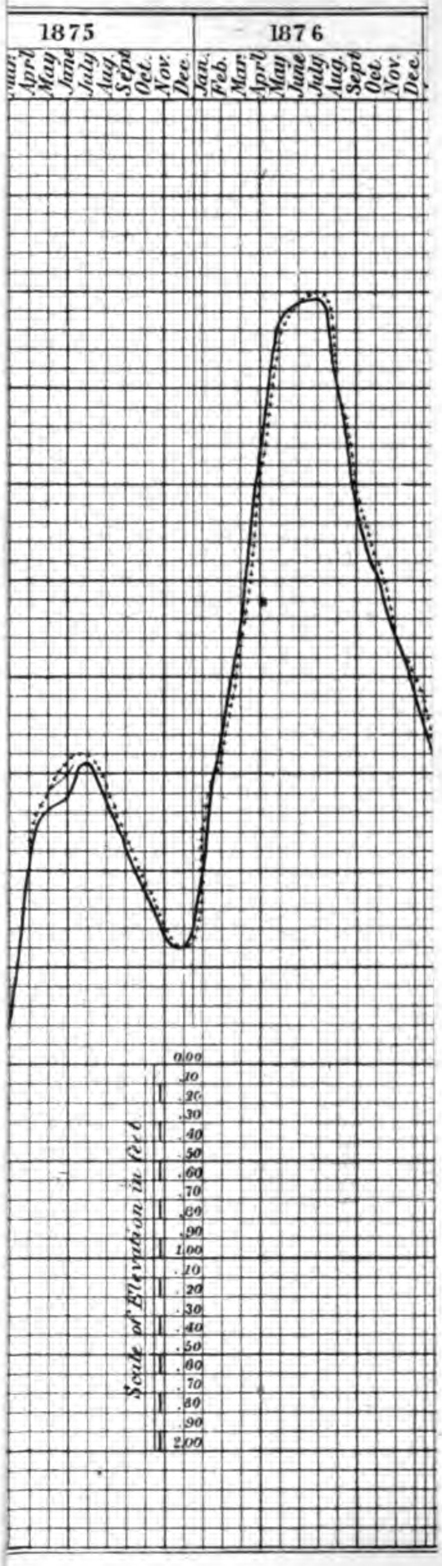
A. R. FLINT,
Assistant Engineer.

General C. B. COMSTOCK.

Mean monthly water-levels for the several stations, in feet and decimals, below the planes of reference adopted in 1876.

[Continuation of table in Appendix No. 9, Annual Report of the United States Lake Survey for 1879. See Appendix M M, Report of the Chief of Engineers for 1879.]

Stations.	1879.							1880.				
	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.
Charlotte	2.05	2.24	2.61	3.01	3.45	3.84	3.82	3.60	3.30	2.98	2.75	2.54
Sacket's Harbor	2.04	2.21	2.57	2.94	3.39	3.77	3.67	3.53	3.21	2.96	2.70	2.52
Cleveland	2.11	2.08	2.30	2.63	2.86	3.33	3.07	2.57	2.53	2.39	2.23	1.96
Erie	2.02	2.03	2.30	2.54	2.69	3.09	2.99	2.53	2.11	2.24	2.00	1.8[illegible]
Detroit	2.20	2.10	2.31	2.50	2.79	3.10	2.87	2.59	3.02	2.60	2.44	2.26
Milwaukee	3.30	3.21	3.40	3.52	3.74	3.96	3.93	3.80	3.98	3.94	3.77	3.43
Escanaba	3.26	3.14	3.36	3.49	3.63	4.11	4.01	......	......	......	3.67	3.3[illegible]
Port Austin	3.37	3.23	3.37	3.52	3.65	3.97	4.05	4.04	4.00	4.07	3.98	3.5[illegible]
Marquette	4.08	3.84	3.72	3.83	3.74	3.82	......	......	......	......	......	......
Sault Ste. Marie	3.93	3.70	3.61	3.69	3.66	3.84	4.24	4.43	4.47	4.56	......	......


1875
1876
April
May
June
July
Aug.
Sept
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept
Oct.
Nov.
Dec.
Scale of Elevation in feet
0.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
2.00

APPENDIX No. 8.

CHARTS.

1.—CATALOGUE OF PUBLISHED LAKE SURVEY CHARTS, JUNE 30, 1880.

Index chart number.	Name of chart.	Scale.	Year of publication.
	Lake Superior.		
36	Lake Superior, No. 3	1-400,000	1873
32	Lake Superior, No. 2	1-400,000	1870
31	Lake Superior, No. 1	1-400,000	1872
25	West end Lake Superior	1- 32,000	1863
38	Isle Royale, Lake Superior	1-120,000	1872
17	Ontonagon Harbor	1- 16,000	1859
16	Eagle River, Lake Superior	1- 10,000	1859
11	Eagle Harbor, Lake Superior	1- 5,000	1858
12	Agate Harbor, Lake Superior	1- 10,000	1858
28	Copper Harbor, Lake Superior	1- 10,000	1866
30	Portage Lake and River	1- 30,000	1865
29	L'Anse and Keweenaw Bay	1- 30,000	1866
34	Huron Island	1- 30,000	1869
20	Marquette Harbor	1- 50,000	1860
24	Grand Island	1- 25,000	1862
	River Saint Marie.		
13	River Saint Marie, No. 1	1- 40,000	1858
5	East Neebish Rapids, River Saint Marie	1- 15,000	1854
14	River Saint Marie, No. 2	1- 40,000	1858
	Straits of Mackinac.		
4	Straits of Mackinac	1-120,000	1856
	Lake Michigan.		
33	North end Lake Michigan	1-400,000	1867
50	South end Lake Michigan	1-400,000	1876
10	Beaver Island Group	1-120,000	1857
27	North end Green Bay	1-120,000	1864
35	South end Green Bay	1-120,000	1864
55	Coast chart No. 1, Lake Michigan	1- 80,000	1877
54	Coast chart No. 2, Lake Michigan	1- 80,000	1877
52	Coast chart No. 3, Lake Michigan	1- 80,000	1876
59	Coast chart No. 4, Lake Michigan	1- 80,000	1877
40	City of Chicago	1- 20,000	1874
51	Coast chart No. 5, Lake Michigan	1- 80,000	1876
57	Coast chart No. 6, Lake Michigan	1- 80,000	1877
58	Coast chart No. 7, Lake Michigan	1- 80,000	1877
63	Coast chart No. 8, Lake Michigan	1- 80,000	1878
62	Coast chart No. 9, Lake Michigan	1- 80,000	1878
26	Grand and Little Traverse Bays	1-120,000	1868
	Lake Huron.		
22	Lake Huron	1-400,000	1869
21	Presque Isle and Middle Island	1- 40,000	1860
19	Thunder Bay	1- 40,000	1860
18	Saginaw Bay	1-120,000	1869
9	Tawas Harbor	1- 16,000	1857
6	Saginaw River	1- 10,000	1856
47	Sand Beach Harbor of Refuge	1- 8,000	1876
23	South end Lake Huron	1-120,000	1861
	Saint Clair River.		
37	Saint Clair River	1- 40,000	1872
	Lake Saint Clair.		
41	Lake Saint Clair	1- 50,000	1874
	Detroit River.		
56	Detroit River	1- 40,000	1876
	Lake Erie.		
75	Lake Erie	1-400,000	1880
15	Maumee Bay, Lake Erie	1- 30,000	1858
2	West end Lake Erie	1-120,000	1852
72	Coast chart No. 6, Lake Erie	1- 80,000	1879
3	Kelly's and Bass Islands	1- 50,000	1852
43	Sandusky Bay	1- 20,000	1874
70	Coast chart No. 4, Lake Erie	1- 80,000	1879
69	Coast chart No. 3, Lake Erie	1- 80,000	1879
68	Coast chart No. 2, Lake Erie	1- 80,000	1879
8	Buffalo Harbor	1- 30,000	1857
	Niagara River.		
48	Niagara Falls	1- 10,000	1876

1.—CATALOGUE OF PUBLISHED LAKE SURVEY CHARTS, JUNE 30, 1880—Continued.

Index chart number.	Name of chart.	Scale.	Year of publication.
	Lake Ontario.		
61	Lake Ontario	1-400,000	[illegible]
67	Coast chart No. 5, Lake Ontario	1- 80,000	[illegible]
66	Coast chart No. 4, Lake Ontario	1- 80,000	[illegible]
65	Coast chart No. 3, Lake Ontario	1- 80,000	[illegible]
64	Coast chart No. 2, Lake Ontario	1- 80,000	[illegible]
60	Coast chart No. 1, Lake Ontario	1- 80,000	[illegible]
	Saint Lawrence River.		
53	Saint Lawrence River, No. 6	1- 30,000	[illegible]
49	Saint Lawrence River, No. 5	1- 30,000	[illegible]
46	Saint Lawrence River, No. 4	1- 30,000	[illegible]
45	Saint Lawrence River, No. 3	1- 30,000	[illegible]
44	Saint Lawrence River, No. 2	1- 30,000	[illegible]
42	Saint Lawrence River, No. 1	1- 30,000	[illegible]

2.—TABLE SHOWING THE ANNUAL ISSUE OF CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES.

Prior to October 1, 1857	2,500
October 1, 1857, to October 1, 1858	1,675
October 1, 1858, to October 1, 1859	2,600
October 1, 1859, to October 1, 1860	4,[illegible]
October 1, 1860, to October 1, 1861	3,254
October 1, 1861, to October 1, 1862	5,245
October 1, 1862, to October 1, 1863	4,0[illegible]
October 1, 1863, to October 1, 1864	3,2[illegible]
October 1, 1864, to October 1, 1865	2,5[illegible]
October 1, 1865, to July 1, 1866	2,0[illegible]
July 1, 1866, to July 1, 1867	5,464
July 1, 1867, to July 1, 1868	6,354
July 1, 1868, to July 1, 1869	5,634
July 1, 1869, to July 1, 1870	4,597
July 1, 1870, to July 1, 1871	5,328
July 1, 1871, to July 1, 1872	3,649
July 1, 1872, to July 1, 1873	6,546
July 1, 1873, to July 1, 1874	7,701
July 1, 1874, to July 1, 1875	5,039
July 1, 1875, to July 1, 1876	4,101
July 1, 1876, to July 1, 1877	3,156
July 1, 1877, to June 1, 1878	6,623
June 1, 1878, to July 1, 1879	4,499
July 1, 1879, to July 1, 1880	4,402

3.—LIST OF PUBLISHED MISSISSIPPI RIVER CHARTS, JUNE 30, 1880.

Number.	Name of chart.	Scale.	Year of publication.
1	Mississippi River, vicinity of Cairo, Ill	1-10,000	1878
2	Mississippi River, vicinity of Cairo, Ill	1-10,000	1878
3	Mississippi River, vicinity of Cairo, Ill	1-10,000	1878
4	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
5	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
6	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
7	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
8	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
9	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1878
	(Published by the Mississippi River Commission.)		
10	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
11	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
12	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
13	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
14	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
15	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879
16	Mississippi River, vicinity of Memphis, Tenn	1-10,000	1879

4.—LIST OF TRACINGS FURNISHED TO PARTIES FROM JULY 1, 1879, TO JUNE 30, 1880.

Name.	Date.	Locality.
Maj. G. Weitzel, Corps of Engineers...	Aug. 4, 1879	Frying Pan Island and vicinity, Saint Mary's River.
Maj. H. M. Robert, Corps of Engineers	Sept. 2, 1879	Chaquamegon Point and vicinity, Lake Superior.
William T. Casgrain, civil engineer....	Oct. 27, 1879	Whitefish Bay, Lake Michigan.
Maj. J. M. Wilson, Corps of Engineers.	Jan. 23, 1880	Maumee Bay, Lake Erie.
Do..............................	Jan. 30, 1880	Maumee River, in front of Toledo.

APPENDIX No. 9.

LIST OF ORIGINAL MANUSCRIPT DETAIL-SHEETS OF THE LAKE SURVEY.

LAKE SUPERIOR.

1. Shore-line and topography.
2. Off-shore hydrography.
3. Harbor and miscellaneous.

1. TOPOGRAPHICAL CHARTS—LAKE SUPERIOR.

No.	Locality.	Date.	Scale.	Topographer, &c.
S. 1	From 3½ miles northwest of Waiska Bay to 11½ miles west of same.	1855	1-15, 840	Lieut. G. W. Rose.
S. 2	From Salt Point to Tahquamenon Point, 9½ miles	1867	1-16, 000	A. Molitor.
S. 3	From Tahquamenon Point to 12½ miles north of same.	1867	1-16, 000	Do.
S. 4	From 4 miles southwest of Whitefish Point to 12 miles west of same.	1867	1-16, 000	Do.
S. 5	From 11¼ miles west of Whitefish Point to 2½ miles west of Two-Hearted River	1867	1-16, 000	Do.
S. 6	From 1 mile west of Two-Hearted River to 14 miles west of same (¼ mile west of Sucker River.)	1867	1-16, 000	J. R. Mayer.
S. 7	From Sucker River to 3½ miles east of Grand Marais..	1867	1-16, 000	Do.
S. 8	From 3½ miles east of Grand Marais to 7¼ miles west..	1867	1-16, 000	Do.
S. 9	From 2 miles southeast of Pointe au Sable to 11 miles southwest of same.	1867	1-16, 000	Do.
S. 10	From 10½ miles southwest of Pointe au Sable to Castle Point.	1867	1-16, 000	Do.
S. 11	Northern part of Grand Island and south shore from Castle Point to 2 miles southwest of same, and from 3 miles east of Train Point to Train Point, including Williams and Wood Islands.	1859	1-16, 000	G. W. Lamson.
S. 12	Southern part of Grand Island and south shore from Castle Point to Train Point, including Wood and Williams Islands.	1859	1-16, 000	Do.
S. 13	From Train Point to 1½ miles southwest of Laughing-Fish Point.	1867	1-16, 000	H. Gillman.
S. 14	From 1½ miles southwest of Laughing-Fish Point to 8¾ miles west of Shot Point.	1867	1-16, 000	Do.
S. 15	Marquette Harbor and shore from 5½ miles southeast to 3½ miles north.	1859	1-16, 000	G. W. Lamson.
S. 16	From Big Presqu Isle Point to Garlic Point, including Middle Island.	1866	1-16, 000	A. Molitor.
S. 17	From 1 mile south of Garlic Point to Touais Point, including Granite Island.	1866	1-16, 000	Do.
S. 18	From ½ mile south of Touais Point to 7 miles northwest of Big Bay Point.	1866	1-16, 000	Do.
S. 19	From 2 miles southeast of Pine River Point to Huron River Point, including Pine Lakes.	1866	1-16, 000	Do.
S. 20	From Huron River Point to 6 miles west of Huron River, including Huron Islands and Pointe Abbaye.	1866	1-16, 000	J. R. Mayer.
S. 21	Part of Huron and Keweenaw Bays from 1½ miles west of Pointe Abbaye to 5 miles northeast of Pequaquawaming Point.	1866	1-16, 000	Do.
S. 21½	Keweenaw Bay from 5 miles northeast of Pequaquawaming Point to 2 miles northeast of same.	1865	1-16, 000	D. F. Henry.
S. 22	From 2 miles northeast of Pequaquawaming Point to 3 miles south of Portage Entry.	1864	1-16, 000	H. Gillman.
S. 23	From 4½ miles south of Portage Entry to 3½ miles northeast of same.	1863	1-16, 000	J. U. Mueller.
S. 23½	Portage River and Portage Entry to Portage Lake....	1868	1- 8, 000	Do.
S. 24	Portage Lake to ½ mile east of Houghton, including part of Torch Bay to 4 miles northeast of Portage Lake.	1863	1-16, 000	Do.
S. 24a	From ½ mile east of Houghton to northwest end of the Lake, including Houghton and Hancock.	1863	1-16, 000	Do.

1. TOPOGRAPHICAL CHARTS—LAKE SUPERIOR—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
S. 24*b*	From 4 miles northeast of Portage Lake to Torch Lake, including Torch River.	1863	1- 8,000	Do.
S. 24*c*	Torch Lake	1864	1-16,000	H. Gillman.
S. 24*d*	From Portage Entry light-house to a point 5 miles northeast of same.	1865	1-16,000	A. Molitor.
S. 25	Keweenaw Point, from 4 miles northeast of Portage Entry light to 2½ miles north of Traverse Point, including Traverse Island.	1865	1-16,000	Do.
S. 25½	Topographical map of Keweenaw Point, including the Portage Lake district and to 8 miles northeast of Traverse Point, including Traverse Island.	1865	1-32,000	Do.
S. 26	Keweenaw Point, from 2 miles north of Traverse Point to 13 miles northeast of same.	1865	1-16,000	Do.
S. 27	Keweenaw Point, from 10 miles southwest of Lac La Belle to Lac La Belle ship-canal.	1865	1-16,000	Do.
S. 27½	Keweenaw Point, from Lac La Belle and Eagle Harbor eastward.	1865	1-32,000	J. R. Mayer.
S. 28	Keweenaw Point, from Lac La Belle to 8 miles east of same.	1865	1-16,000	Do.
S. 29	Keweenaw Point, from 5 miles west to 5½ miles northwest of same, including Manitou Island.	1865	1-16,000	Do.
S. 30	North side of Keweenaw Point from 6 miles east of Copper Harbor to 4 miles west of same.	1864	1-16,000	H. Gillman.
S. 31	North side of Keweenaw Point from 4 miles east of Agate Harbor to 3 miles west of same.	1855	1-10,000	J. U. Mueller.
S. 31¼	From 2½ miles east of Eagle Harbor to 5 miles west of same.	1855	1-10,000	Lieut. W. F. Raynold
S. 31½	From 2¼ miles northeast of Eagle River to 4½ miles southwest of same.	1855	1-10,000	Do.
S. 32	From 4½ miles southwest of Eagle River to 16 miles southwest of same.	1865	1-16,000	H. Gillman.
S. 33	From 16 miles southwest of Eagle River to 31 miles southwest of same.	1865	1-16,000	Do.
S. 34	From 31 miles southwest of Eagle River to 42 miles southwest of same.	1865	1-16,000	Do.
S. 35	From 2½ miles northeast of Misery River to 10½ miles southwest of same.	1865	1-16,000	Do.
S. 36	From ½ mile northeast of Fire-Steel River to 6 miles southwest of Ontonagon.	1855	1-16,000	Lieut. W. F. Raynold
S. 37	From 6 miles southwest of Ontonagon to 7 miles west of Iron River.	1868	1-16,000	Lieut. J. E. Griffith.
S. 38	From 6 miles west of Iron River to 3 miles southwest of Carp River.	1868	1-16,000	Do.
S. 39	From 3½ miles northeast of Presqu Isle River to 6 miles southwest of Black River.	1868	1-16,000	Do.
S. 40	From 5 miles southwest of Black River to ½ mile west of Montreal River.	1868	1-16,000	H. Gillman.
S. 41	From Montreal River to 1 mile northwest of Clinton Point.	1868	1-16,000	Do.
S. 42	From Clinton Point to Oak Point, 6 miles northwest of Bad River.	1869	1-16,000	A. C. Lamson.
S. 43	From Oak Point to 7 miles north of Ashland, including part of Chaquamegon Bay.	1869	1-16,000	Do.
S. 44	Part of Chaquamegon Bay, including Oak Point, Chaquamegon Point, part of Magdalene Island, and west shore from McClellan to 4 miles south of Bayfield.	1869	1-16,000	Do.
S. 45	From 4 miles south of Bayfield to 3 miles north of same, including part of Magdalene Island.	1869	1-16,000	Do.
S. 46	From 3 miles north of Bayfield to 9 miles north, including part of Basswood and Hermit Islands, and Oak and Raspberry Islands.	1869	1-16,000	J. R. Mayer and A. Lamson.
S. 47	Part of Magdalene and Michigan Islands	1869	1-16,000	Capt. J. A. Smith.
S. 48	Stockton Island	1869	1-16,000	Do.
S. 49	Outer Island	1869	1-16,000	Do.
S. 49¼	Outer Island	1872	1-16,000	Capt. J. A. Smith.
S. 49½	Otter, Ironwood, and Manitou Islands	1870	1-16,000	Lieut. J. H. Weeden.
S. 50	Bear, Devil, Rocky, South Twin, North Twin, Cat, and part of Otter Islands.	1869	1-16,000	Capt. J. A. Smith a Lieut. J. H. Weede
S. 51	From 9 miles north of Bayfield to 5 miles west of Sand River, including York, Sand, Eagle, and Steamboat Islands.	1869	1-16,000	J. R. Mayer.
S. 52	From 6 miles northeast of Siskiwit Bay to 6 miles southwest of Bark Point, including Bark and Siskiwit Bays.	1869	1-16,000	Do.
S. 53	From 6 miles northeast of Flag River to 5 miles west of Iron Ore River.	1869	1-16,000	Do.
S. 54	From 1 mile east of Bois Brulé River to 6 miles west of same.	1861	1-16,000	H. C. Penny.
S. 55	From 6 miles west of Bois Brulé River to 4 miles east of Superior City.	1861	1-16,000	Do.
S. 56	From 4 miles east of Superior City to 7 miles northwest of same, including Allouez, Saint Louis, and Superior Bays, and Wisconsin, Minnesota, Rice's and Grassy Points.	1861	1-16,000	W. H. Hearding.

1. TOPOGRAPHICAL CHARTS—LAKE SUPERIOR—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
S. 57	Saint Louis River, from head of Saint Louis Bay to Fond du Lac.	1861	1-16,000	Do.
S. 58	Northwest shore of Lake Superior, from 7 miles northwest of Superior City to 14 miles northeast of same.	1861	1-16,000	H. C. Penny.
S. 59	From 3½ miles west of Buchanan, to include Burlington Bay.	1861	1-16,000	Do.
S. 60	From Burlington Bay to 6½ miles northeast of Gooseberry River, including Encampment Island.	1868	1-16,000	J. R. Mayer.
S. 61	North shore, from 5 miles southwest of Beaver Bay to Petit Marais.	1868	1-16,000	Do.
S. 62	From Petit Marais to 9 miles northeast of Temperance River, including Two Island River.	1868	1-16,000	Do.
S. 63	From ½ mile southwest of Poplar River to 1 mile northeast of Fall River, including Good Harbor Bay.	1868	1-16,000	H. Gillman.
S. 64	From 1½ miles west of Grand Marais to 7½ miles northeast of same.	1868	1-16,000	Lieut. W. E. Rogers and A. Molitor.
S. 65	From 7½ miles north of Grand Marais to 6 miles east of Brulé River.	1868	1-16,000	Do.
S. 66	From 6 miles east of Brulé River to Grand Portage Bay.	1868	1-16,000	Do.
S. 67	From Grand Portage Bay to 2 miles northeast of Pine River Bay, including Grand Portage Island, Wauswau-goning Bay, Susie, Lucille, Belle Rose, and Brick Islands, Pigeon River and Bay, and Pine River Bay.	1868	1-16,000	Do.
S. 67½	Grand Portage Bay	1861	1-10,000	James Carr and E. P. Austin.
S. 68	North shore Isle Royale, including Brace and Washington Harbors and coast 5 miles northeast of same, and Washington Island.	1868	1-16,000	Lieut. J. C. Mallery and A. C. Lamson.
S. 69	From 5 miles northeast of Washington Harbor to 13½ miles northeast.	1868	1-16,000	Do.
S. 70	Isle Royale, from 3 miles southwest of Todd's Harbor to 1 mile northeast of McCargoe's Cove.	1868	1-16,000	Do.
S. 71	East coast Isle Royale, from 1 mile northeast of McCargoe's Cove northeast 5½ miles, and south shore from Chippewa Harbor to Caribou Island.	1868	1-16,000	Lieut. B. D. Greene and A. C. Lamson.
S. 72	Northeast Isle Royale, from Green Island around Blake's Point to Mott's Island, including Duncan's Bay, Tobin's Harbor, Rock Harbor, and Canoe Rock.	1868	1-16,000	Do.
S. 72½	Passage Island, Gull Island, and Bateau Rock (northeast end of Isle Royale).	1867	1-24,000	Lieut. J. F. Gregory.
S. 73	Isle Royale, from 4 miles east of Siskiwit Lake to 1 mile south of same.	1868	1-16,000	Lieuts. B. D. Greene and L. M. Haupt.
S. 74	From 1 mile south of Siskiwit Lake, to include Siskiwit Bay.	1868	1-16,000	Do.
S. 75	From Siskiwit Bay to 13½ miles west of same	1868	1-16,000	Do.
S. 81	Isle Saint Ignace	1871	1-40,000	G. A. Marr.

2.—HYDROGRAPHICAL CHARTS—LAKE SUPERIOR.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
S. A.	Southeast end of Lake Superior, from Iroquois Island to Castle Rock.	1867	1-120,000	Capt. F. U. Farquhar.
S. B.	From Castle Rock to Train Point	1859	1-32,000	J. A. Potter.
S. C.	From Laughing-Fish Point to Wood Island	1867	1-120,000	Capt. F. U. Farquhar.
S. D.	From Laughing-Fish Point to Ontonagon	1865 1866 1868	1-170,000	Capt. F. U. Farquhar, D. F. Henry, and A. C. Lamson.
S. E.	From Wood Island to Ontonagon	1864 1865 1866 1867 1868	1-200,000	Capt. F. U. Farquhar, D. F. Henry, W. H. Hearding, and A. C. Lamson.
S. F.	Off Chocolate River	1859	1-5,000	G. W. Lamson.
S. G.	Marquette Harbor	1859	1-5,000	Do.
S. H.	Off Agate Harbor	1855	1-5,000	Lieut. W. F. Raynolds.
S. I.	......do	1855	1-4,000	Do.
S. J.	Off Eagle Harbor	1855	1-4,000	Do.
S. K.	Off Eagle River	1855	1-4,000	Do.
S. L.	......do	1855	1-10,000	Do.
S. M.	From Ontonagon to 130 miles northeast of Superior City.	1861 1868	1-200,000	Capt. F. U. Farquhar, Lieut. J. F. Gregory, and James Carr.
S. N.	Off Ontonagon	1855	1-30,000	Lieut. W. F. Raynolds.

2. HYDROGRAPHICAL CHARTS—LAKE SUPERIOR—Continued.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
S. O.	From Bad to Brulé River	1860	1-120,000	Capt. J. A. Smith and Lieut. J. C. Mallery.
S. P.	From Brulé River to 9 miles northeast of Buchanan	1861	1-60,000	James Carr.
S. Q.	Off shore Isle Royale	1867 1868	1-200,000	Lieut. J. F. Gregory.
S. R.	East end Isle Royale, from Green Island to Bateau Rock.	1867	1-96,000	Lieut. J. F. Gregory.
S. S.	Off Stannard's Rock	1866	1-5,000	D. F. Henry.
S. T.	Part of White-Fish Bay, from Gros Cap to Maple Island, including Parisian Island.	1868	1-32,000	O. N. Chaffee.

3.—HARBOR AND MISCELLANEOUS CHARTS—LAKE SUPERIOR.

No.	Locality.	Date.	Scale.	Topographer, &c.
S. 14½	Mouth of Chocolate River and shore, from ¾ mile east to ¾ mile west, and showing Chocolate River for ½ mile.	1867	1-4,000	H. Gillman.
S. 17½	Granite Island	1866	1-500	A. Molitor.
S. 20½	Huron Island	1866	1-4,000	J. R. Mayer.
S. 30½	Copper Harbor, including Fort Wilkins	1864	1-5,000	H. Gillman.
S. 36½	Mouth of Ontonagon River and shore for ½ mile northeast and southwest of same.	1865	1-5,000	Do.
S. 56½	Entrance to Superior Bay	1866	1-5,000	E. S. Wheeler.
S. 62½	Sketch of mouth of Two-Island River	(?)	1-2,000	(?)
S. 76	Isle Saint Ignace and harbor	1869	1-8,000	G. A. Marr.
S. 77	Simmons' Harbor, northeast coast of Lake Superior	1869	1-10,000	A. R. Flint.
S. 78	Sketch showing connection with shore from Station Paugon.	1869	1-8,000	G. A. Marr.
S. 79	Sketch showing triangulation of Lake Superior and deep-sea soundings.	1867	1-633,000	(?)
S. 91	Village of Eagle Harbor	1851	1-1,600	W. Schlatter.

SAINT MARY'S RIVER.

1. Shore-line and topography.
2. Miscellaneous.

1.—TOPOGRAPHICAL CHARTS—SAINT MARY'S RIVER.

No.	Locality.	Date.	Scale.	Topographer, &c.
St. M. 2	Part of Potaganissing Bay, including part of Drummond Island and Saint Joseph and Harbor Island.	1854	1-15,840	Capt. E. P. Scammon.
St. M. 3	Part of Potagonissing Bay and Mud Lake, including Lime Island.	1854	1-15,840	Do.
St. M. 4	Part of Mud Lake, including part of Saint Joseph and Sailors' Encampment Island.	1854	1-15,840	Do.
St. M. 5	North end of Mud Lake, including south end of Hay Lake, Sailors' Encampment Island, and Middle and West Neebish Rapids.	1854	1-15,840	Do.
St. M. 6	North end of Hay Lake, Sugar Island Rapids, and part of Sugar Island.	1854	1-15,840	Do.
St. M. 7	Little Lake George and north end of Sugar Island.	1853	1-15,840	Do.
St. M. 8	East part of Sugar Island and south part of Sand Island.	1854	1-15,840	Capt. E. P. Scammon and Lieut. G. H. Mendell.
St. M. 11	Lake George	1853 1857	1-15,840	Do.
St. M. 12	......do	1857	1-15,840	Capt. A. W. Whipple.
St. M. 17	River Saint Mary, from 2 miles east of Sault Ste. Marie to 7½ miles west.	1855	1-15,840	Lieut. G. W. Rose.
St. M. 18	From 7½ miles west of Sault Ste. Marie to Gros Cap, 3½ miles northwest of Waiska Bay.	1855	1-15,840	Do.
St. M. 19	From 3½ miles northwest of Waiska Bay to 11½ miles west of same.	1855	1-15,840	Do.

2.—MISCELLANEOUS CHARTS—SAINT MARY'S RIVER.

No.	Locality.	Date.	Scale.	Topographer, &c.
St. M. 10	Middle Neebish	1854?	1-7, 920	Capt. E. P. Scammo
St. M. 13	Flats of Lake George, improved channel	1863	1-5, 000	O. N. Chaffee.
St. M. 14	......do	1864	1-5, 000	W. H. Hearding.
St. M. 15	......do	1868?	1-2, 000	O. N. Chaffee.
St. M. 16	Lake George, east channel	(?)	1-7, 920	(?)
St. M. 21	Channel of Lake George	1863	....	O. N. Chaffee.

LAKE HURON AND STRAITS OF MACKINAC.

1. Shore-line and topography.
2. Off-shore hydrography.
3. Harbor and miscellaneous.

1.—TOPOGRAPHICAL CHARTS—LAKE HURON AND STRAITS OF MACKINAC.

No.	Locality.	Date.	Scale.	Topographer, &c.
H. 1	South end of Lake Huron and west shore, from 1 mile east of Fort Gratiot to 2 miles north of Lakeport, including Port Huron and Sarnia.	1859	1-16, 000	W. H. Hearding.
H. 2	From 1 mile north of Lakeport to 3 miles north of Lexington.	1859	1-16, 000	Do.
H. 3	West shore, from 3 miles north of Lexington to 1 mile north of Port Sanilac.	1858	1-16, 000	Do.
H. 4	From ½ mile north of Port Sanilac to 4½ miles north of Cherry Creek.	1858	1-16, 000	Do.
H. 5	From 3 miles north of Cherry Creek to 4 miles north of Forestville.	1858	1-16, 000	Do.
H. 6	From 3 miles north of Forestville to 4 miles north of Barnetville.	1858	1-16, 000	Do.
H. 7	From 4 miles north of Barnetville to 1 mile south of Pointe aux Barques light-house.	1858	1-16, 000	Do.
H. 8	Northeast shore Saginaw Bay, from 1 mile south of Pointe aux Barques light-house to 1½ miles south of Pointe aux Barques.	1857	1-16, 000	Do.
H. 9	Saginaw Bay, from 1 mile southeast of Pointe aux Barques to 1¾ miles southwest of Hat Point, including Point aux Barques, Port Austin, Flat Rock Point, Partridge, and Hat Points.	1857	1-16, 000	Do.
H. 10	From Hat Point to ½ mile south of Oak Point	1857	1-16, 000	Do.
H. 11	From Oak Point to Sand Point	1856	1-16, 000	Lieut. C. N. Turnbul
H. 12	From Sand Point to 2 miles northeast of Sebewaing, including Sand Point, Wild Fowl Bay, North Island, Stony Island, and Ka-te-chay Island.	1857	1-16, 000	Lieut. O. M. Poe.
H. 13	From 2 miles northeast of Sebewaing to 11½ miles southwest of same.	1857	1-16, 000	H. C. Penny.
H. 14	South shore Saginaw Bay from 4 miles northeast of Quannakissee to 7 miles northwest of same.	1857	1-16, 000	W. H. Hearding.
H. 15	From 3 miles east of the mouth of Saginaw River to 6 miles northwest of same.	1856	1-16, 000	Do.
H. 17	From 4½ miles northwest of Saginaw River to 1 mile north of O-pin-kaw-ning River.	1856	1-16, 000	Do.
H. 18	From 1 mile north of O-pin-kaw-ning River to 2 miles southwest of Pine River.	1857	1-16, 000	G. W. Lamson.
H. 19	From 4 miles south of Pine River to 2 miles north of Pointe au Grès.	1857	1-16, 000	Do.
H. 20	West shore Saginaw Bay from Pointe au Grès to 3 miles north of Gravelly Point, including South Charity and part of North Charity Islands and Au Grès River.	1857	1-16, 000	Do.
H. 21	From 2½ miles southwest of White Stone Point to ¾ of a mile southwest of Tawas City.	1857	1-16, 000	Do.
H. 22	West shore Lake Huron from 1½ miles southwest of Tawas City to 2 miles north of Pointe au Sable, including Tawas Point and Harbor and Pointe au Sable.	1856	1-16, 000	Do.
H. 23	From 3 miles southwest of Pointe au Sable to 6 miles north of Sable River.	1856	1-16, 000	Do.
H. 24	West shore Lake Huron from 6 miles north of Sable River to Harrisville.	1858	1-16, 000	H. C. Penny.
H. 25	From ½ mile south of Harrisville to 1½ miles north of Black River, including Sturgeon Point and Black River Island.	1858	1-16, 000	Do.
H. 26	From Black River to 5 miles northwest of South Point.	1858	1-16, 000	G. W. Lamson.
H. 27	From 2 miles southeast of Devil River to ½ mile east of White-Fish Point, including Sulphur Island, Partridge Point, Alpena, and Thunder Bay.	1858	1-16, 000	Do.

1.—TOPOGRAPHICAL CHARTS, LAKE HURON, &C.—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
H. 28	From 1 mile northwest of White-Fish Point to 5 miles northwest of North Point, including North Point, part of Thunder Bay, Crooked Island, &c.	1858	1-16,000	Do.
H. 29	From 5 miles northwest of North Point to ½ mile south of False Presqu' Isle, including Middle Island and part of False Presqu' Isle.	1858	1-16,000	H. C. Penny.
H. 30	From 1½ miles south of False Presqu' Isle to 3 miles north of Presqu' Isle, including False Presqu' Isle Harbor and Presqu' Isle Harbor and island.	1858	1-16,000	Do.
H. 30½	From 2 miles southeast of Presqu' Isle to 2½ miles northwest of Adam's Point.	1844	1-12,000	Lieut. J. W. Gunnison and L. L. Locklin.
H. 30¾	From 2½ miles northwest of Adam's Point to opposite Bois Blanc Island.	1844	1-12,000	Lieut. J. W. Gunnison and L. L. Locklin.
H. 31	From 3 miles northwest of Presqu' Isle to 3 miles west of Adam's Point.	1859	1-16,000	H. C. Penny.
H. 32	From 3 miles west of Adam's Point to 7 miles northwest of Trout River.	1859	1-16,000	Do.
H. 33	From 6½ miles east of Ocqueoc River to 7 miles northwest of same, including Hammond's Bay.	1859	1-16,000	Do.
H. 34	Straits of Mackinac from Pointe Brulée to Beaver-Tail Point, including Pointe Brulée, Gull Point, Marquette Bay, Goose Island, Jake's Island, Isle La Sable, Scammon's Harbor, Isle William, Isle Isidore, &c.	1851	1-15,840	Lieut. E. P. Scammon.
H. 34½	Straits of Mackinac from Pointe Brulée to Beaver-Tail Point, continued, including Boot-Jack Island, Strong's Island, Mackinac Point, Whist Island, Surveyor's, Tobin's, and Martin's Reefs, &c.	1851	1-15,840	Do.
H. 35	Straits of Mackinac from Beaver-Tail Point to mouth of St. Mary's River (Détour Passage), including Point St. Vital and Point Détour.	1851	1-15,840	Do.
H. 36	North shore Lake Huron, part of Drummond Island, from 7 miles east of Detour Passage to include Harbor Island.	1859	1-16,000	W. H. Hearding.
H. 37	From ½ mile west of Harbor Island to Point Smith of Cockburn Island, including part of Drummond and Cockburn Islands and False Détour Channel.	1859	1-16,000	Do.
H. 38	From ½ mile east of Fort Gratiot to 1½ miles east of Errol, including Perch River.	1859	1-16,000	H. C. Penny.
H. 39	From 3 miles southwest of Point Harris to 1¼ miles south of Cape Ipperwash.	1859	1-16,000	Do.
H. 40	From 1¼ miles south of Cape Ipperwash to 1 mile east of Sable River, including Cape Ipperwash.	1859	1-16,000	Do.
H. 43	North shore of Straits of Mackinac and entrance to St. Mary's River to 3½ miles north of same.	1853	1-15,840	Capt. E. P. Scammon and Lieut G. H. Mendell.
H. 59	Map of Mackinac Island	1853	1-16,000	J. Lambert.

2.—HYDROGRAPHICAL CHARTS—LAKE HURON.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
H. A.	From Cape Ipperwash around to Elk Creek, 3½ miles south of Forestville.	1859	1-60,000	Capt. Geo. G. Meade and Lieut. W. P. Smith.
H. B.	From Cherry Creek, 6 miles north of Port Sanilac, to ½ mile south of Stafford.	1859	1-60,000	Capt. Geo. G. Meade
H. C.	From 3 miles south of Forestville to 3½ miles north of Sable River, giving off-shore soundings from Oak Point to Pointe au Sable, from Saginaw River to O-pin-kawning River, and from Twas to 3½ miles north of Sable River.	......	1-128,000	Capt. H. W. Bayfield.
H. D.	From Oak Point to 3 miles west of Sebewaing, including Charity Islands.	1857 / 1858	1-32,000	Capt. Geo. G. Meade.
H. E.	Charity Island	1856	1-16,000	Lieut. C. N. Turnbull and D. F. Henry.
H. F.	From Sable River to Thunder Bay	1859	1-60,000	J. A. Potter.
H. G.	Thunder Bay, from Black River to Crooked Island	1858	1-40,000	Capt. Geo. G. Meade.
H. H.	From Thunder Bay to Presqu' Isle	1859	1-40,000	J. A. Potter.
H. I.	From Presqu' Isle to 8 miles northwest of Hammond's Bay.	1859	1-60,000	Do.
H. J.	From Point St. Vital to Smith's Point and Cockburn Island.	1859	1-60,000	Do.
H. K.	From Cape Ipperwash to Sable River	1860	1-60,000	(?)
H. L.	Saginaw Bay and around Pointe aux Barques (two sheets in large roll).	1858	1-40,000	Capt. G. G. Meade.

3.—HARBOR AND MISCELLANEOUS CHARTS—LAKE HURON AND STRAITS OF MACKINAC.

No.	Locality.	Date.	Scale.	Topographer, &c.
H. 41	Outline of Lake Huron, with soundings	......	1–318, 300	Capt. Bayfield.
H. 42	Map of triangulation of Lake Huron	......	1–500, 000	
H. 44	Spectacle Reef	1849	1–5, 280	Lieut. J. N. Macomb.
H. 47	Straits of Mackinac, index map showing triangulation	......	1–120, 000	
H. 53	Village of Port Hope	......	1–5, 333	E. Molitor.

LAKE MICHIGAN, GREEN BAY, AND STRAITS OF MACKINAC.

1. Shore-line and topography.
2. Off-shore hydrography.
3. Harbors and miscellaneous.

1.—TOPOGRAPHICAL CHARTS—LAKE MICHIGAN, GREEN BAY, AND STRAITS OF MACKINAC.

No.	Locality.	Date.	Scale.	Topographer, &c.
M. 1	West shore of Lake Michigan from 2½ miles southwest of Two Rivers to 5 miles north of Molosh Creek, including Two Rivers and Rawley's Point.	1866	1–16, 000	Henry Gillman.
M. 2	From Two Creeks to 2½ miles north of Kewaunee, including Dean's.	1866	1–16, 000	Do.
M. 3	From 2½ miles north of Kewaunee to 6 miles northeast of Ahnepee.	1866	1–16, 000	Do.
M. 4	From 6 miles northeast of Ahnepee to 7½ miles northeast of Portage.	1866	1–16, 000	Do.
M. 5	West shore from 2 miles southwest of White-Fish Point to 6 miles north of Cave Point, including White-Fish Bay.	1866	1–16, 000	Do.
M. 6	From 3½ miles south of Bayley's Harbor to Cana Island, including Bayley's Harbor and Cana Island.	1863	1–16, 000	J. R. Mayer.
M. 7	From Cana Island to 2 miles northeast of Rawley's Bay, including North Bay and Spider Island.	1863	1–16, 000	Do.
M. 8	From 2 miles northeast of Rawley's Bay to Table Bluff, including Gravelly Island, Pilot, Detroit, and Plum Islands and Porte des Morts.	1862 / 1863	1–16, 000	Do. / A. Molitor.
M. 9	Porte des Morts channel, including shore-line from 3 miles northeast of Rawley's Bay to 6 miles north of same, also Plum and Pilot Islands.	1862	1–16, 000	O. N. Chaffee.
M. 10	Southeast shore Green Bay from 2 miles southeast of Table Bluff to 1 mile southwest of Deaths' Door Bluff, including Hedgehog Harbor.	1863	1–16, 000	H. Gillman.
M. 11	From ½ mile southwest of Deaths' Door Bluff to 3 miles northwest of Eagle Bay, including Ellison's Bay, Sister Bluff, Sister Islands and Shoals, Horseshoe Islands and Reefs, &c.	1863	1–16, 000	Do.
M. 12	Green Bay from 3 miles northwest of Eagle Bay to one mile west of Egg Harbor, including Strawberry Island.	1862 / 1865	1–16, 000	H. C. Penny and A. C. Lamson.
M. 13	From 1 mile west of Egg Harbor to 12 miles south of same.	1865	1–16, 000	A. C. Lamson.
M. 14	Sturgeon Bay, including town of Sturgeon, Sawyer's Harbor, Sherwood's Point, &c.	1865	1–16, 000	Do.
M. 14½	Reduced maps of Big and Little Sturgeon Bays, including shore-line of Green Bay to 3 miles north of Big Sturgeon Bay and 3 miles west of Little Sturgeon Bay.	1865	1–30, 000	Lieut. L. M. Haupt.
M. 15	From 1 mile northwest of Sherwood's Point to 6 miles southwest of Little Sturgeon Bay.	1865	1–16, 000	A. C. Lamson.
M. 16	From 6 miles southwest of Little Sturgeon Bay to 18 miles southwest of same.	1865	1–16, 000	Do.
M. 17	From 18 miles southwest of Little Sturgeon Bay to Red Banks.	1865	1–16, 000	A. C. Lamson and A. F. Chaffee.
M. 18	Head of Green Bay, showing the shore-line from ½ mile northeast of Red Banks to 3 miles southwest of Sable Point, and from Fox River to 3 miles north of Duck Creek, including Long Tail Point, soundings, &c.	1865	1–16, 000	O. N. Chaffee.
M. 19	Fox River from its mouth to Depere, 7 miles from same, including Green Bay City and Fort Howard.	1865	1–16, 000	Do.
M. 20	From Long Tail Point to 7 miles northeast of Little Suamico River, including Big Suamico River and Little Tail Point.	1865	1–16, 000	A. F. Chaffee.
M. 21	From 3 miles south of Pensaukee to 4½ miles north of Oconto, including Pensaukee and Oconto River.	1865	1–16, 000	Do.

1.—TOPOGRAPHICAL CHARTS, LAKE MICHIGAN, &C.—Continued.

No.		Locality.	Date.	Scale.	Topographer, &c.
M.	22	From 4 miles north of Oconto to ¾ mile north of Peshtigo Point.	1865	1-16,000	A. F. Chaffee.
M.	23	From Peshtigo Point to 2 miles north of Menomonee, including Little River, Menomonee River, and Burn, Green, Stevenson's, Jacobs, and Grassy Islands.	1865	1-16,000	Do.
M.	24	From 1¾ miles north of Menomonee to 6¾ miles north of same.	1864	1-16,000	A. Molitor.
M.	25	West shore Green Bay from 2¼ miles southwest of Abbot's to 1¼ miles northeast of Brooks', including J. Williams' and Point Rochereau.	1864	1-16,000	Do.
M.	26	From 6 miles southwest of Cedar River to 8½ miles northeast of same.	1663	1-16,000	H. C. Penny.
M.	27	Green Bay from 4 miles southwest of Bark River to 2 miles northeast of Ford River, including Indian Town.	1863	1-16,000	Do.
M.	28	Mouth of Little Bay de Nocquette from Ford River to 4 miles north of Escanaba River and from Peninsula Point to 12 miles northwest of same.	1864	1-16,000	H.C. Penny and H.G[illegible]man.
M.	29	Head of Little Bay de Nocquette from 3 miles north of Escanaba River around to 11 miles northwest of Peninsula Point, including Sander's Point, Day River, Masonville, Rapid River, &c.	1863	1-16,000	O. N. Chaffee, H. C. Penny.
M.	30	West shore of Big Bay de Nocquette from Peninsula Point to 2½ miles north of Chippewa Point, including Round Island.	1864	1-16,000	A. F. Chaffee.
M.	31	Big Bay de Nocquette from 1½ miles north of Chippewa Point to Indian Point, including Ripley's Shoal, Saint Vital Point and Island, and Pickerel River.	1864	1-16,000	Do.
M.	32	From 1 mile north of Indian Point to ½ mile northeast of Porcupine Point, including Sturgeon River, Stony and Poplar points.	1864	1-16,000	Do.
M.	33	From ½ mile west of Porcupine Point around to Ansel's Point, including Big Fish-dam River, Little-Fish-dam River, Jack's Bluff, and Valentine's Point.	1864	1-16,000	J. R. Mayer and A. F. Chaffee.
M.	34	East shore of Big Bay de Nocquette from ¾ mile northeast of Ansel's Point to 1 mile south of Snail-Shell Harbor, including Garden Bay, Garden Creek, Garden Bluff, South River Bay, &c.	1864	1-16,000	J. R. Mayer.
M.	35	Big Bay de Nocquette from ½ mile south of Snail-Shell Harbor to ¾ mile northeast of Point Détour, including Burnt Bluff, Jack Bay, &c.	1864	1-16,000	Do.
M.	36	Poverty, Gravely, Gull, Little Gull, and Saint Martin Island at entrance of Green Bay.	1864	1-16,000	Do.
M.	37	Rock, Washington, and Hog islands entrance to Green Bay, including Jackson's, Washington, and Detroit Harbors, Boyer's Bluff, &c.	1863 1864	1-16,000	O. N. Chaffee and S. W. Robinson.
M.	38	Whale's Back Shoal, Green Bay	1863	1-16,000	W. H. Hearding.
M.	39	Chambers Island	1864	1-16,000	A. Molitor.
M.	40	Northwest coast Lake Michigan from Point Détour to 1¼ miles south of Portage Bay.	1864	1-16,000	W. T. Casgrain.
M.	41	From 2 miles south of Portage Bay to Bourassa's Point, including Portage Bay, Parent Bay, Miller's Point, and Pointe aux Barques.	1864	1-16,000	Do.
M.	42	From Bourassa's Point to ¾ mile northeast of Farnsworth's Point, including Wiggin's Point, &c.	1864	1-16,000	Do.
M.	43	From Farnsworth's Point to Seul Choix Pointe	1855	1-16,000	W. H. Hearding.
M.	44	From 2 miles north of Seul Choix Pointe to 1 mile northeast of Scott's Point, including Hughes' Point.	1855	1-16,000	Do.
M.	45	North shore of Lake Michigan from Scott's Point to 9¾ miles northeast of Patterson Point.	1854	1-16,000	G. W. Lamson.
M.	46	From 6¾ miles northeast of Patterson Point to 3 miles northeast of Biddle Point.	1854 1855	1-16,000	Do.
M.	47	Straits of Mackinac from 2¾ miles east of Biddle Point to 2¾ miles east of Pointe Époufette.	1853	1-15,840	Lieut. G. W. Rose.
M.	48	From Pointe Époufette to 10 miles southeast of Manitou Payment, including Manitou Payment Shoals.	1852	1-15,840	Lieut. E. P. Scammon.
M.	49	From 5 miles north of Pointe aux Chênes to 1½ miles east of Little Pointe aux Chênes.	1852	1-15,840	Do.
M.	60	From 1½ miles northwest of Gros Cap to Point St. Ignace, including part of St. Helena Island, Mackinac Island, Gros Cap, &c.	1853	1-15,840	Lieut. W. F. Raynolds.
M.	51	Straits of Mackinac from Pointe St. Ignace to Rabbit's Back Point, and south shore from Old Fort Mackinac to 5¾ miles southeast of same.	1852	1-15,840	Do.

1.—TOPOGRAPHICAL CHARTS, LAKE MICHIGAN, &C.—Continued.

No.		Locality.	Date.	Scale.	Topographer, &c.
M.	52	From Pointe St. Ignace to Pointe Fuyard, including East Moran Bay, Rabbit's Back Point, Groose Pointe, Carp and Pine rivers, Pointe St. Martin, St. Martin's Bay, Search Bay, Pointe Brulée, Grosse Isle, Gull Point, Goose Island, Marquette Bay, and part of Isle Marquette.	1849	1-15, 840	Lieut. E. P. Scammon.
M.	52½	From Pointe St. Ignace to Pointe Fuyard	1849	1-15, 840	Do.
M.	53	From 16¾ miles southeast of Cheboygan light-house to 3¾ miles southeast of same.	1851	1-15, 840	Lieut. W. F. Raynolds.
M.	54	From 4½ miles southeast of Cheboygan to 1½ miles west of Pointe au Sable, including McLeod's Bay, Duncan City, and part of Bois Blanc Island.	1851	1-15, 840	Do.
M.	55	Bois Blanc Island	1849	1-15, 840	R. W. Burgess.
M.	56	From 1½ miles southeast of Pointe au Sable to Old Mackinac Point.	1851	1-15, 840	Lieut. W. F. Raynolds.
M.	57	Straits of Mackinac, from 3 miles southeast of Old Fort Mackinac to 13½ miles west of same.	1852	1-15, 840	Do.
M.	58	From 3¾ miles east of Point Waugoshance, to include Cross Village, &c.	1853	1-15, 840	Do.
M.	59	Straits of Mackinac, including part of Waugoshance Island and Waugoshance Light-house, White Shoal, Gray's Reef, and Hat Island.	1853	1-15, 840	Do.
M.	60	Hog and Hat Islands and Hog Island Reef	1854	1-16, 000	Do.
M.	61	Garden, Squaw, and Whisky Islands	1854	1-16, 000	Do.
M.	62	Part of Big Beaver and Garden Islands	1854	1-16, 000	Do.
M.	63	Beaver Island	1855	1-16, 000	W. H. Hearding.
M.	64	South end of Beaver Island	1855	1-16, 000	Do.
M.	65	Parts of High, Gull, and Trout Islands	1855	1-16, 000	G. W. Lamson.
M.	66	Gull Island (north end of Lake Michigan)	1855	1-16, 000	Do.
M.	67	North and South Fox Islands	1860	1-16, 000	D. F. Henry.
M.	67½	South Fox Island	1862	1-16, 000	J. R. Mayer.
M.	68	Straits of Mackinac, from Cross Village to 2¾ miles south of Middle Village, including Isle aux Galets.	1853	1-15, 840	Lieut. W. F. Raynolds.
M.	69	Lake Michigan, from 2¼ miles north of Middle Village to 2¼ miles north of Little Traverse.	1860	1-16, 000	W. H. Hearding.
M.	70	Little Traverse Bay, including coast from 3 miles northwest of Little Traverse to 5 miles west of Bear Creek.	1860	1-16, 000	Do.
M.	71	From 4½ miles west of Bear Creek to 3½ miles southwest of Big Rock Point.	1860	1-16, 000	Do.
M.	72	From 1½ miles northeast of Pine River to 9 miles southwest of same.	1860	1-16, 000	Do.
M.	73	From 3 miles north of New York Point to 11½ miles south of same, including part of Torchlight Lake.	1860	1-16, 000	Do.
M.	74	Grand Traverse Bay, from 10 miles north of Elk Rapids to Petibico, 3½ miles south of same.	1860	1-16, 000	Do.
M.	75	From 3½ miles south of Petibico to Deep-Water Point.	1860	1-16, 000	Do.
M.	76	From 3½ miles southwest of Deep-Water Point to 6 miles southwest of Bower's Harbor, including Old Mission, Tucker's Point, Bower's Harbor, and Hog Island.	1860	1-16, 000	D. F. Henry.
M.	77	From 6 miles northeast of Traverse City to 8 miles northwest of same, including Traverse City.	1860	1-16, 000	H. C. Penny and D. F. Henry.
M.	78	West arm of Grand Traverse Bay from 5 miles southwest of Lee's Point to 1 mile northeast of Pishauby's Village, including Lee's Point, Sutton's Point and Bay.	1860	1-16, 000	H. C. Penny and H. Gillman.
M.	79	Grand Traverse Bay from 1½ miles south of Dougherty's Harbor to 4½ miles southwest of light-house, including New Mission Point, Northport Bay, Northport and Northport Point, and Light-House Point,	1860	1-16, 000	Do.
M.	80	Lake Michigan from Cat-Head Point to ½ mile north of Leland, including Nominese Village.	1860	1-16, 000	Do.
M.	81	From Leland to 3 miles northwest of North Unity, including Carp River, Good Harbor Bay, and North Unity.	1860	1-16, 000	Do.
M.	82	North and South Maniton Island	1860	1-16, 000	D. F. Henry.
M.	83	From 1 mile east of Pyramid Point to 3 miles south of Sleeping Bear Point, including Pyramid Point and Glen Arbor.	1860	1, 16, 000	H. C. Penny and H. Gillman.
M.	84	From Sleeping Bear Point to Pointe aux Becs Scies, including Empire Bluffs and Platte River Point.	1860	1-16, 000	Do.
M.	85	From 1 mile north of Pointe aux Becs Scies Light-house to 2 miles south of Herring Lake, including Frankfort, Lake aux Becs Scies, and Herring Lake.	1866	1-16, 000	A. F. Chaffee.
M.	86	East shore Lake Michigan from 3½ miles north of North Bar Lake to ¼ mile south of Portage Lake.	1866	1-16, 000	Do.

1.—TOPOGRAPHICAL CHARTS, LAKE MICHIGAN, &c.—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
M. 87	From Portage Lake to 3 miles southwest of Manistee Lake, including Rush Lake and Manistee Lake.	1866	1-16,000	A. F. Chaffee.
M. 88	From 4 miles northeast of Free Soil to 8 miles southwest of same.	1866	1-16,000	Do.
M. 89	East Shore Lake Michigan, from 2½ miles north of Big Point Sable to 3 miles south of Ludington, including Hamlin, Lincoln, Ludington, and Pere Marquette Lake.	1866	1-16,000	Do.
M. 90	From 6 miles north of Bass Lake to 3½ miles southwest of Pentwater.	1866	1-16,000	Do.
M. 91	From 3 miles southwest of Pentwater to Little Point Sable.	1866	1-16,000	Do.
M. 92	From Little Point Sable to Clay Banks, including Benona and Stony Creek.	1870	1-20,000	Lieut. W. R. Livermore and G. A. Marr.
M. 93	From Clay Banks to 5 miles south of White Lake, including Whitehall and Montague.	1871	1-20,000	L. Foote.
M. 94	From 5 miles south of White Lake to 2 miles south of Muskegon Lake, including Muskegon, Laketon, Bluffton, and Port Sherman.	1871	1 -2,000	Do.
M. 95	From 2 miles south of Muskegon Lake to 6 miles south of Grand Haven, including Spring Lake, Grand River, Grand Haven, and Fruitport.	1871	1-20,000	Do.
M. 97	From 6 miles south of Grand Haven to entrance of Black Lake, including Black Lake and Holland.	1871	1-20,000	Do.
M. 97½	From Black Lake to 1 mile north of Kalamazoo River.	1871	1-20,000	Do.
M. 98	From 1 mile north of Kalamazoo River to 11 miles south of Kalamazoo River, including Saugatuck, Douglas, Pier Cove, and Kalamazoo River, 2 miles from its mouth.	1871	1-20,000	H. Custer.
M. 99	From 10 miles south of Kalamazoo River to 6 miles south of South Haven.	1871	1-20,000	Do.
M. 100	From 6 miles south of South Haven to 13 miles south of same, including Saint Paul.	1871	1-20,000	Do.
M. 101	From 13 miles south of South Haven to 8 miles south of Saint Joseph, including Saint Joseph River, Paw-Paw River, Grand Marais.	1871	1-20,000	Do.
M. 103	Entrance to Kalamazoo River, including 4 miles of same and the towns of Saugatuck and Douglas.	1871	1-10,000	Do.
M. 106	From Grand Marais to Wilkin's Landing...........	1872	1-20,000	Do.
M. 107	From Michigan City to 12 miles west of same, including Michigan City.	1871	1-20,000	L. Foote.
M. 108	From 12 miles west of Michigan City to 3 miles west of Grand Calumet River.	1871	1-20,000	Do.
M. 109	From Wilkin's Landing to Michigan City, including New Buffalo.	1872	1-20,000	H. Custer.
M. 110	From Calumet River to Robertsdale Station	1872	1-20,000	J. R. Mayer.
M. 111	From Robertsdale Station to 5 miles north of Calumet or South Chicago, including South Chicago.	1872	1-20,000	Do.
M. 113	From 1¼ miles south of Chicago to 2½ miles north of Chicago.	1872	1-20,000	Do.
M. 116	Showing positions of Azimuth Stations on both shores.	......	....	
M. 117	From 2 miles north of Chicago to 9 miles north of Chicago, including Evanston.	1873	1-10,000	H. Custer.
M. 118	From 8 miles north of Chicago to 21 miles north of same, including Wilmette, Winetka, Highland Park.	1873	1-20,000	Do.
M. 118½	From 10 miles south of Waukegan to 5 miles north of same, including town of Waukegan.	1873	1-20,000	Do.
M. 119	From 11 miles south of Kenosha to 3 miles north of same, including Kenosha.	1872	1-20,000	Do.
M. 121	From 3 miles north of Kenosha to 12 miles north of Racine, including Racine.	1872	1-20,000	Do.
M. 124	West shore of Lake Michigan, from 4 miles south of Oak Creek to Oak Creek.	1871	1-20,000	J. R. Mayer.
M. 125	From Oak Creek to 4 miles north of Milwaukee	1871	1-20,000	Do.
M. 127	From 4 miles north of Milwaukee to Ulao, including Kempersville.	1871	1-20,000	Do.
M. 128	From Ulao to Amsterdam, including Port Washington.	1871	1-20,000	Do.
M. 129	From 1 mile south of Amsterdam to 1 mile south of Sheboygan, including Amsterdam and Black River.	1870	1-20,000	Do.
M. 131	From 1 mile south of Sheboygan to 2 miles north of Centerville, including Sheboygan, Pigeon River, Linzville, and Centerville.	1870	1-20,000	Do.
M 132	From ½ mile south of Yorkville to 3½ miles northeast of Manitowoc, including Yorkville, Nordheim, Calvin's Creek, Silver Creek, &c.	1870	1-20,000	Do.

1.—TOPOGRAPHICAL CHARTS, LAKE MICHIGAN, &c.—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
M. 133	Sketch showing triangulation of northeast end of Lake Michigan.	Old..	1-180,000	(?)
M. 134	North end of Lake Michigan	Old..	1-180,000	(?)
M. 135	Primary and secondary triangulation of northeast part of Lake Michigan.	1867	1-400,000	(?)
M. 137	Green Bay, from Fox River to 1 mile south of Little Sturgeon Bay.	1843	1-12,000	Lieut. Jas. H. Simpson
M. 138	From 1 mile south of Little Sturgeon Bay to 2½ miles northeast of Cedar Creek.	1843	1-12,000	Do.
M. 139	From 2½ miles northeast of Cedar Creek to 11 miles northeast of Big Sturgeon Bay; also St. Martin's Island.	1843	1-12,000	Do.
M. 141	From 6 miles north of Pointe aux Becs Scies to Manistee River.	1844	1-12,000	Lieut. J. W. Gunnison.
M. 142	From Manistee to Grand River	1844	1-12,000	Do.

2.—HYDROGRAPHICAL CHARTS—LAKE MICHIGAN AND GREEN BAY.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
M A...	Off-shore hydrography, from 16 miles south of Sheboygan to 7 miles north of same.	1870	1-60,000	Lieut. A. N. Lee.
M B...	From 7 miles north of Sheboygan to Kewaunee	1870	1-60,000	Do.
M C...	From 8 miles south of Kewaunee to Bayley's Harbor.	1866	1-60,000	O. N. Chaffee.
M D...	From Bayley's Harbor to Point Détour	1863	1-60,000	W. H. Hearding.
M E...	From head of Green Bay to Red River Bluffs	1865	1-60,000	O. N. Chaffee.
M F...	From Red River Bluffs to Sister Bluffs	1865	1-60,000	Do.
M F½..	From Chamber's Island to Sister Bluff	1864	1-60,000	A. C. Lamson.
M G...	From Sister Bluff to Escanaba (Little Bay de Nocquette).	1863	1-60,000	W. H. Hearding.
M G½..	Entrance to Porte des Morts and Whale's Back Shoal.	1862	1-60,000	Do.
M H...	Big Bay de Nocquette	1864	1-60,000	O. N. Chaffee.
M I...	Off-shore hydrography of northwest shore of Lake Michigan from Pointe Détour to Farnsworth's Point.	1864	1-60,000	W. H. Hearding.
M J...	From Seul-Choix Pointe to Straits of Mackinac	(?)	1-80,000	(?)
M K ..	Lithographed chart of north end of Lake Michigan, with a few lines of deep-sea soundings.	1870	1-400,000	Lieut. A. N. Lee.
M L...	Straits of Mackinac, chart with deep-sea soundings.	1871	1-120,000	Lieut. Chas. F. Powell.
M M ..	Lithographed chart of Beaver Group with deep-sea soundings.	1871	1-120,000	Do.
M N...	Off-shore hydrography from Seul-Choix to Pointe aux Chênes.	1855	1-120,000	Reduced.
M O...	Off-shore hydrography about the Fox Islands, Lake Michigan.	(?)	1-32,000	(?)
M P...	From Middle Village to Pointe aux Becs Scies	1860	1-120,000	J. A. Potter.
M Q...	North shore of Lake Michigan, with a few deep-sea soundings.	1867	1-200,000	O. N. Chaffee.
M R...	From Pointe aux Becs Scies to Big Point Sable	1866	1-60,000	Do.
M S ..	From Big Point Sable to Little Point Sable	1866	1-60,000	Do.
M T...	Off-shore hydrography of northeast shore of Lake Michigan and Straits of Mackinac from Pointe Époufette and Hat Island to Détour Light-house.	(?)	1-120,000	(?)
M U...	From 6½ miles northeast of Point Patterson to 3 miles northeast of Biddle Point, showing certain shallow places.	1871	1-16,000	Lieut. C. F. Powell.
M V...	West shore Lake Michigan from 5 miles north of Fox Point to 5 miles south of Oak Creek.	1871	1-60,000	Lieut. A. N. Lee.
M W ..	East shore Lake Michigan from Little Point Sable to the south, 45 miles.	1870 1871	1-60,000	Lieut. A. N. Lee and Lieut. J. H. Werden.
M X...	Lines of soundings across the lake	1870 1872	....	Capt. A. N. Lee.
M Y...	Off-shore hydrography east shore Lake Michigan from Twin Sisters to South Haven.	1872	1-60,000	Do.
M Z...	From 4 miles south of South Haven to 10 miles north of New Buffalo.	1872	1-60,000	Do.
M Aa..	From 10 miles north of New Buffalo to 21 miles west of Michigan City.	1873	1-60,000	Lieut. D. W. Lockwood.
M Bb..	From 21 miles west of Michigan City to 20 miles north of Chicago.	1873	1-60,000	Do.
M Cc..	From 20 miles north of Chicago to 10 miles north of Racine.	1873	1-60,000	Do.

3.—HARBOR AND MISCELLANEOUS CHARTS—LAKE MICHIGAN, GREEN BAY, AND STRAITS OF MACKINAC.

No.	Locality.	Date.	Scale.	Topographer, &c.
M. 9½	Engraved chart of Green Bay	1846	1-126,320	Capt. W. G. Williams.
M. 56½	Straits of Michilimackinac (in large roll)	1841	1- 31,680	Do.
M. 84½	Mouth of River Aux Bees Scies, including coast from same for 1 mile north and 1½ miles south.	1859	1- 5,000	Lieut. O. M. Poe.
M. 87½	Sketch of mouth of Manistee River	1861	1- 4,000	J. Barney.
M. 96	Grand River Harbor, including Grand Haven	1866	1- 2,400	John de la Camp.
M. 102	Saint Joseph's Harbor and coast for ¾ mile north and ¾ mile south of same.	1865	1- 5,000	E. B. Wright.
M. 114	Map of city and harbor of Chicago	1865	1- 3,600	E. S. Chesebrough.
M. 115	Map of entrance to Chicago Harbor	1865	1- 600	Do.
M. 121½	City harbor of Racine, including reef from 2½ miles south of light-house to 2 miles north of same.	1873	1- 10,000	Henry Custer.
M. 122	Harbor of Racine	1865	1- 4,800	A. W. Unthank.
M. 123	Map showing position and character of reef near Racine Harbor.	1867	1- 9,600	W. T. Casgrain.
M. 124½	City of Milwaukee, Wis	1873	1- 10,000	Henry Custer.
M. 130	Map of harbor of Sheboygan	1865	1- 500	A. W. Unthank
M. 140	Entrance to Green Bay, including Chamber's Island, Plum, Detroit, Washington, and Rock Islands.	1842	1- 2,400	Lieut. J. H. Simpson.
M. 155	Mouth of Grand River	1844	1- 6,000	Lieut. J. W. Gunnison.
M. 156	Mouth of Kalamazoo River	1844	1- 6,000	Do.
M. 157	Manistee Harbor	1866	1- 2,400	W. T. Casgrain.
M. 158	Soundings north of Garden Island		1- 16,000	
M. 160	South Manitou Island	1843?	1- 12,000	Lieut. J. N. Macomb.
M. 167	Beaver Island Group and part of north shore, showing sections and part of triangulation.	(?)	1- 80,000	(?)
M. 168	Shoals and soundings in north end of Lake Michigan	1853	1- 4,800?	(?)
M. 171	South end of Lake Michigan, showing cross-sections with profile.	1874	1- 80,000	J. U. Mueller and F. A. Fisher.

LAKE AND RIVER SAINT CLAIR.

1. Shore-line and topography.
2. Hydrography.
3. Miscellaneous.

1.—TOPOGRAPHICAL CHARTS—LAKE AND RIVER SAINT CLAIR.

No.	Locality.	Date.	Scales.	Topographer, &c.
St. C. 1	Both shores of Saint Clair River from Lake Huron to Mooretown, including Mooretown, Port Huron, Huron, Sarnia, Stag Island, and Vicksburg.	1867	1- 16,000	Lieut. James Mercur.
St. C. 2	From Mooretown to Marine City, including both sides of the river, Mooretown and Saint Clair.	1867	1- 16,000	Lieut. B. D. Greene.
St. C. 3	From Marine City to Algonac, both sides of river, including Marine City, Sombra, Woodtick Island, &c.	1807	1- 16,000	Do.
St. C. 4a	From Algonac to light-house and beacon, including Walpole Island, Russel Island, Point Aux Chênes, Huron Island, &c.	1868	1- 16,000	O. N. Chaffee.
St. C. 4c	Delta of river Saint Clair	1868	1- 16,000	Lieut. B. D. Greene.
St. C. 4d	do	1856	1- 16,000	W. H. Hearding.
St. C. 5	From North Channel to light-house	1868	1- 16,000?	J. R. Mayer.
St. C. 6	From New Baltimore to Belvidere	1868	1- 16,000	Do.
St. C. 7	From Huron Point to Grosse Point	1868	1- 16,000	A. Molitor.
St. C. 8	Lake Saint Clair, including Grosse Point and Isle au Pêche.	1868	1- 16,000	Lieut. J. F. Gregory and A. Molitor.
St. C. 9	From 1¾ miles northwest of Pike Creek to 1¼ miles east of Duck Creek.	1868	1- 16,000	Lieut. J. F. Gregory.
St. C. 14	Saint Clair Flats, from ship-canal to Mitchell's Point, including Bassett's Channel, Blind Channel, Johnston's Channel, and Chenal Ecarté.	1871	1- 20,000	Lieut. W. R. Livermore and F. M. Towar.
St. C. 15	South shore Lake Saint Clair, from a point about 6 miles west of Pointe Aux Roches to a point 4½ miles east of the same.	1871 1872	1- 20,000	J. R. Mayer and V. T. McGillicuddy.
St. C. 16	From the Thames River to Mitchell's Point	1871	1- 20,000	A. C. Lamson.
St. C. 17	Upper part of Chenal Ecarté and Johnston's Channel.	1871	1- 20,000	F. M. Towar.

2.—HYDROGRAPHICAL CHARTS—LAKE AND RIVER SAINT CLAIR.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
St. C. 12	Off-shore hydrography of Lake Saint Clair	1868		Lieut. J. F. Gregory.
St. C. 13	Relative positions of the off-shore sounding of Lake Saint Clair from an assumed base.			Lieut. J. H. Weeden.

3.—MISCELLANEOUS CHARTS—LAKE AND RIVER SAINT CLAIR.

No.	Locality.	Date.	Scale.	Topographer, &c.
	Delta of Saint Clair River	1856		
St. C. 10a	Lake Saint Clair Flats Improvement Survey	1859	3- 16, 000	G. W. Lamson.
St. C. 10b	do	1859	3- 16, 000	Do.
St. C. 10c	do	1860	1- 3, 000	D. F. Henry.
St. C. 10d	do	1861	1- 3, 000	Do.
St. C. 10e	do	1863	1- 3, 000	Do.
St. C. 10f	do	1864	1- 3, 000	Do.
St. C. 10g	do	1867	1- 3, 000	O. N. Chaffee.
St. C. 10h	do	1868	1- 3, 000	Capt. F. U. Farquhar.
St. C. 11	Saint Clair Flats Canal	1870	1- 3, 000	Lieut. A. N. Lee.
St. C. 18	Description of bench-mark	1867	1- 8, 000	Capt. G. J. Lydecker.
St. C. 21	Scheme of main triangulation	1867	1-177, 500?	(?)
St. C. 23	Saint Clair Flats Ship-Canal	1872	1- 1, 200	Lieut. D. W. Lockwood.

DETROIT RIVER.

Shore-line and topography.

TOPOGRAPHICAL CHARTS—DETROIT RIVER.

No.	Locality.	Date.	Scale.	Topographer, &c.
D. 7	From Lake Saint Clair to Belle Isle	1873	1-10, 000	A. C. Lamson.
D. 8	From Belle Isle to western city limits of Detroit	1873	1-10, 000	Do.
D. 9	From western city limits of Detroit to Delray	1873	1-10, 000	Do.
D. 10	From 1 mile north of Fighting Island to Riviere Aux Canards, including towns of Ecorse and Wyandotte, and part of Grosse Isle.	1873	1-10, 000	Do.
D. 11	From Trenton to Bar Point, including towns of Trenton, Gibraltar, and Amherstburg, and Grosse Isle, and Bois Blanc.	1873	1-10, 000	Do.
D. 12	Mouth of Detroit River, including Bar Point and Pointe Mouillée.	1873	1-10, 000	Do.

LAKE ERIE.

1. Shore-line and topography.
2. Off-shore hydrography.
3. Harbors and miscellaneous.

1.—TOPOGRAPHICAL CHARTS—LAKE ERIE.

No.	Locality.	Date.	Scale.	Topographer, &c.
E. 1	West end of Lake Erie, from Grosse Isle to Pointe Mouillée, including Pointe Pelée.	1848	1-63, 360	Lieut. J. N. Macomb.
E. 10	From Pointe Pelée to Station No. —	1847	1-15, 840	Lieutenant Gunnison.
E. 15	Cedar Point, showing channel at entrance to Sandusky Bay.	1862	1-10, 000	W. H. Hearding.
E. 16½	Shore-line from Sandusky Bay to south bend of lake.	1847?	1-15, 840	Lieut. Col. James Kearney.
E. 23	Maumee River	1857	1-10, 000	W. H. Hearding.
E. 25	Sandusky Bay, from Cedar Point to Johnston's Island, including Sand Point and Johnston's Island.	1872	1-10, 000	A. C. Lamson.
E. 26	From Johnston's Island to Railroad Bridge	1872	1-10, 000	Do.
E. 32	River Raisin		1-12, 000	
E. 71	Long Point, Ontario	1875	1-10, 000	J. R. Mayer.

1.—TOPOGRAPHICAL CHARTS—LAKE ERIE—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
E. 72	From Morgan's Point to 1½ miles east of Port Colborne, Ontario, including Port Colborne.	1875	1–10,000	John Eisenmann.
E. 73	From 1½ miles east of Port Colborne, Ontario, to 1½ miles east of Point Abino, including Point Abino.	1875	1–10,000	Do.
E. 74	From 1½ miles east of Point Abino, Ontario, to 8 miles east of same, including village of Ridgeway, Ontario, also Windmill Point.	1875	1–10,000	Do.
E. 75	From Buffalo, N. Y., to about 5½ miles south of same, including Smoke Creek and West Hamburg.	1875	1–10,000	J. R. Mayer.
E. 76	From 5½ miles south of Buffalo to 9 miles south of same.	1875	1–10,000	Do.
E. 77	From 9 miles south of Buffalo to 14 miles southwest of same, including Eighteen-Mile Creek.	1875	1–10,000	Do.
E. 78	From 2½ miles east of Sturgeon Point to 6½ miles east of Irving, N. Y.	1875	1–10,000	A. C. Lamson.
E. 79	From 6½ miles east of Irving to 1½ miles east of same	1875	1–10,000	Do.
E. 80	From 1½ miles east of Irving, N. Y., to 4½ miles west of Silver Creek, N. Y., including village of Silver Creek.	1875	1–10,000	Do.
E. 81	From 4½ miles west of Silver Creek to 1 mile west of Dunkirk, N. Y., including city of Dunkirk.	1875	1–10,000	J. R. Mayer.
E. 82	From 1 mile west of Dunkirk to 7 miles west of same, including Van Buren Point.	1875	1–10,000	Do.
E. 83	From 7 miles west of Dunkirk to 12 miles southwest of same, including Brocton Station.	1875	1–10,000	F. M. Towar.
E. 84	From 12 miles southwest of Dunkirk to 16½ miles southwest of same, to town of Barcelona.	1875	1–10,000	Do.
E. 85	From Barcelona to 7 miles west of same	1875	1–10,000	Do.
E. 86	From 4 miles east of Twenty-Mile Creek to 3 miles west of same, including Twenty-Mile Creek.	1875	1–10,000	John Eisenmann.
E. 87	From Sixteen-Mile Creek to 2 miles west of Twelve-Mile Creek.	1875	1–10,000	Do.
E. 88	From 2 miles west of Twelve-Mile Creek to Erie, Pa	1875	1–10,000	A. C. Lamson.
E. 89	From Erie, Pa., to 2 miles west of same, including city and harbor of Erie and Presqu' Isle.	1875	1–10,000	Do.
E. 90	From 2 miles west of Erie, Pa., to 6 miles west of same.	1875	1–10,000	Do.
E. 91	From 6 miles west of Erie, Pa., to 11 miles west of same, including Walnut Creek.	1875	1–10,000	F. M. Towar.
E. 92	From 11 miles west of Erie, Pa., to 16 miles west of same, including Elk Creek.	1875	1–10,000	Do.
E. 93	From Elk Creek to 2½ miles west of same	1875	1–10,000	Frederick Terry.
E. 94	From 1 mile east of Crooked Creek to 2½ miles west of same.	1875	1–10,000	John Eisenmann.
E. 95	North shore of Long Point, Ontario	1876	1–10,000	F. Terry.
E. 96	do	1876	1–10,000	Do.
E. 97	do	1876	1–10,000	Do.
E. 98	From 4½ miles east of Conneaut Piers, Ohio, to 3½ miles west of same.	1876	1–10,000	J. R. Mayer.
E. 99	From 3 miles west of Conneaut, Ohio, to 5 miles east of Ashtabula, Ohio.	1876	1–10,000	F. M. Towar.
E. 100	From 5 miles east of Ashtabula, Ohio, to Red Creek, 3 miles west of same.	1876	1–10,000	A. C. Lamson.
E. 101	From Red Creek, 3 miles west of Ashtabula, to 5 miles west of same.	1876	1–10,000	F. M. Towar.
E. 102	From 8 miles west of Ashtabula, Ohio, to 13 miles west of same.	1876	1–10,000	Do.
E. 103	From 13 miles west of Ashtabula, Ohio, to 7 miles east of Fairport, Ohio.	1876	1–10,000	Do.
E. 104	From 7 miles east of Fairport, Ohio, to 2½ miles east of same.	1876	1–10,000	A. C. Lamson.
E. 105	From 2½ miles east of Fairport, Ohio, to 4½ miles west of same, including Fairport and Richmond.	1876	1–10,000	Do.
E. 106	From 4½ miles west of Fairport, Ohio, to Chagrin River.	1876	1–10,000	F. M. Towar.
E. 107	From Chagrin River to 1 mile west of line of Cuyahoga County.	1876	1–10,000	Do.
E. 108	From a point 8 miles east of city limits of Cleveland, Ohio, west 4 miles.	1876	1–10,000	F. Terry.
E. 109	From 4 miles east of city limits, Cleveland, Ohio, to western city limits.	1876	1–10,000	Do.
E. 110	City of Cleveland, Ohio	1876	1–10,000	A. C. Lamson.
E. 111	From 4 miles east of Rocky River, Ohio, to 4 miles west of same.	1876	1–10,000	F. M. Towar.
E. 112	From 4 miles west of Rocky River to 6 miles east of Black River, Ohio.	......	....	Do.
E. 113	From 6 miles east of Black River to 2 miles west of same, including Lorain.	1876	1–10,000	F. Terry.
E. 114	From 2 miles west of Black River, Ohio, to 5 miles west of same.	1876	1–10,000	Do.
E. 115	From light-house at Vermilion, Ohio, to 7 miles east of same, including Vermilion, Ohio.	1876	1–10,000	F. M. Towar.

1.—TOPOGRAPHICAL CHARTS—LAKE ERIE—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
E. 116	From Vermilion to Old Woman's Creek, 8 miles west of Vermilion.	1877	1-10,000	F. M. Towar.
E. 117	From Old Woman's Creek to 2½ miles west of Huron River, including village of Huron.	1877	1-10,000	F. Terry.
E. 118	From 2½ miles west of Huron River to 3 miles southeast of Cedar Point.	1877	1-10,000	Do.
E. 119	From 3 miles southeast of Cedar Point, Sandusky Bay, to 2 miles north of Sand Point, including Marblehead light-house.	1877	1-10,000	A. C. Lamson.
E. 120	From Marblehead light-house to East Harbor, inclusive.	1877	1-10,000	A. C. Lamson.
E. 121	From East Harbor, 3 miles northwest, to Scott's Point; thence 2 miles southwest to Moore's Point; thence 1½ miles south, including West Harbor, Ottawa City, Mouse Island, and Sugar Bluff (Catawba Island).	1877	1-10,000	Do.
E. 122	From 1½ miles south of Moore's Point to 3¾ miles south of same.	1877	1-10,000	Do.
E. 123	From 3½ miles east of Portage River to 1½ miles west of same, including Port Clinton.	1877	1-10,000	F. Terry.
E. 124	From 1 mile west of Portage River to 4½ miles west of same.	1877	1-10,000	Do.
E. 125	From 4½ miles west of Portage River to 7½ miles west of same.	1877	1-10,000	Do.
E. 126	From 1 mile east of Touissaint Creek to 2½ miles west of same, or ¾ mile east of Locust Point.	1877	1-10,000	F. M. Towar.
E. 127	From 1 mile east of Locust Point to 6 miles west of same.	1877	1-10,000	Do.
E. 128	From 6 miles west of Locust Point to 4½ miles east of Cedar Point.	1877	1-10,000	A. C. Lamson.
E. 129	From 3½ miles east of Cedar Point to Cedar Point ..	1877	1-10,000	Do.
E. 130	South shore Maumee Bay, from Cedar Point to 2 miles east of Presqu' Isle.	1877	1-10,000	F. M. Towar.
E. 131	Maumee River to its mouth, including city of Toledo and both shores of river.	1877	1-10,000	F. Terry.
E. 132	From 2 miles east of Presqu' Isle to mouth of Maumee River, on south shore, and on west shore from mouth of river to 5 miles north of same, including Grassy Point.	1877	1-10,000	F. M. Towar.
E. 133	Entrance to Maumee Bay, between Cedar Point and Grassy Point, including Turtle Island.	1877	1-10,000	Do.
E. 134	West shore of Lake Erie, from 5 miles north of mouth of Maumee River to 8½ miles north of same, including Turtle Island.	1877	1-10,000	A. C. Lamson.
E. 135	From 8½ miles north of mouth of Maumee River to 13½ miles north of same.	1877	1-10,000	Do.
E. 136	From 3½ miles southwest of Monroe Piers (River Raisin) to 3½ miles north of same.	1877	1-10,000	Do.
E. 137	From 3½ miles west of Stony Point to 4 miles north of same, including Stony Point.	1877	1-10,000	Do.
E. 138	From 4 miles north of Stony Point to Point Mouillée.	1877	1-10,000	Do.
E. 139	From 8 miles west of Colchester Pier to 1 mile west of same (north shore Lake Erie).	1877	1-10,000	F. M. Towar.
E. 140	From 1 mile west of Colchester Pier to 3½ miles west of same, including village of Colchester, Ontario.	1877	1-10,000	Do.
E. 141	North shore of Lake Erie from 1 mile west of Kingsville, Ontario, to 7 miles west of same.	1877	1-10,000	F. Terry.
E. 142	From 1 mile west of Kingsville to 6 miles east of same, including village of Kingsville, Ontario	1877	1-10,000	Do.
E. 143	North shore from 4 miles east of Leamington, Ontario, to 1 mile west of same.	1877	1-10,000	A. C. Lamson.
E. 144	From 2 miles north of southern point of Pointe Pelée to 7 miles north of same, along the western shore, Ontario.	1877	1-10,000	Do.
E. 145	Southern point of Pointe Pelée	1877	1-10,000	F. M. Towar.
E. 145½	Middle Ground Shoal, between Pointe Pelée and Pointe Pelée Island, Ontario.	1877	1-10,000	Do.
E. 146	North end of Pointe Pelée Island	1877	1-10,000	F. Terry.
E. 147	Middle portion of Pointe Pelée Island	1877	1-10,000	Do.
E. 148	Southern end of Pointe Pelée Island	1877	1-10,000	Do.
E. 149	Gull Island Shoal, Lake Erie	1877	1-10,000	A. C. Lamson.
E. 150	Kelley's Island, Lake Erie	1877	1-10,000	Do.
E. 151	South Bass, Green, Ballast, and Starve Islands, and lower part of Middle Bass Island.	1877	1-10,000	F. M. Towar.
E. 152	Middle Bass, North Bass, Rattlesnake, and Sugar Island.	1877	1-10,000	Do.
E. 153	Hen and Chickens, East Sister, and North Harbor Islands, Ontario.	1877	1-10,000	Do.
E. 154	West Sister and Middle Sister Islands	1877	1-10,000	Do.

2.—HYDROGRAPHICAL CHARTS—LAKE ERIE.

No.	Locality.	Date.	Scale.	Hydrographer.
E. A.	Off-shore hydrography around Long Point	1875	1–60,000	Capt. H. M. Adams.
E. B.	East end of Lake Erie from Buffalo to Dunkirk, N. Y., and Canadian shore to Morgan's Point.	1875	1–60,000	Do.
E. C.	Erie, Pa., to Conneaut, Ohio	1875	1–60,000	Capt. H. M. Adams and Lieut. C. F. Powell.
E. D.	From Dunkirk, N. Y., to Erie, Pa	1875	1–60,000	Lieut. C. F. Powell.
E. E.	Off-shore hydrography around Long Point, Ontario	1876	1–60,000	Lieut. P. M. Price.
E. F.	From Conneaut west to Fairport	1876	1–60,000	Do.
E. G.	From Fairport southwest toward Cleveland	1876	1–60,000	Do.
E. H.	From Cleveland to Vermillion, Ohio	1876	1–60,000	Do.
E. I.	From Vermillion to Monroe Piers, including all islands in the west end of Lake Erie.	1877	1–80,000	Lieuts. D. W. Lockwood and P. M. Price.
E. J.	From Monroe Light to Pointe Pelée	1877	1–80,000	Do.

3.—HARBOR AND MISCELLANEOUS CHARTS—LAKE ERIE.

No.	Locality.	Date.	Scale.	Topographer, &c
E. 3	Lake Erie, from Pointe de Peux to Monroe, including Stony Point and harbor of Brest.	1848	....	Lieut. J. W. Gunnison.
E. 4	From River Raisin to Turtle Island and North Cape.	.....	....	
E. 5a	Maumee Bay	1844	1–12,000	Lieut. J. H. Simpson.
E. 5b	Cedar Point and entrance to Maumee Bay	1848	1– 1,000	Lieut. E. P. Scammon.
E. 6	Entrance to Maumee Bay	1868	1– 8,000	Lieut. J. F. Gregory.
E. 6½	......do	1857	1–15,000	W. H. Hearding.
E. 7	From Touissaint River to Search Creek	......	....	
E. 8	West end of Lake Erie, including reef off Pointe Aux Feves, East, West, and Middle Sister, Middle Island, and Hen and Chickens.	......	1– 7,920	
E. 9	From 7 miles west of Cedar Creek to 5 miles northeast of same.	......	....	
E. 11	Bass Islands	1845	....	Lieut. J. C. Woodruff.
E. 12	Reconnoissance in the vicinity of Kelly's and Bass Islands.	1845	....	Lieut. Col. Kearney.
E. 13	From Mouse Island to Marblehead light	1847	....	Lieut. J. N. Macomb.
E. 14	From Marblehead to Port Clinton light	1847	....	Lieut. E. P. Scammon.
E. 16	From 3 miles northwest of Huron River to Cedar Point.	(?)	....	
E. 17	Black River Harbor	1865	1–5,000	W. T. Casgrain.
E. 17½	Ashtabula Harbor	1865	1–5,000	Do.
E. 18	Cleveland Harbor	1865	1–5,000	Do.
E. 19	Grand River Harbor	1865	1–5,000	Do.
E. 19½	Conneaut Harbor	1866	1–5,000	John De La Camp.
E. 20a	Erie Harbor and Presqu' Isle	1866	1–8,000	Do.
E. 20b	Details of Erie Harbor	1866	1–8,000	Do.
E. 21	Sketch of shoal near Buffalo	1859	1–5,000	Lieut. O. M. Poe.
E. 22½	Map of country near Niagara River	......	....	Lieut. J. H. Simpson.
E. 1½	Triangulation of west end of Lake Erie	......	....	
E. 26½	City of Sandusky (field sketch)	1873	....	J. U. Mueller.
E. 28	Cattaraugus Creek	1839	1–1,200	Y. S. Brown.
E. 29	Portland Harbor	......	....	Do.
E. 30	Port Clinton Harbor	1850	1–2,640	Lieut. J. N. Macomb.
E. 31	Mouth of Sandusky River, Ohio	1850	1–2,640	Do.
E. 33	Part of River Raisin	......	1–4,800	Capt. W. O. Williams and J. F. Peter.
E. 36	Huron Harbor	......	1–2,400	Do.
E. 37	......do	......	1–2,400	
E. 38	Cleveland Harbor	......	1–2,400	
E. 39	Harbor, Grand River, Ohio	......	1–2,400	
E. 40	Cattaraugus Harbor	1838?	1–3,900	
E. 41	Conneaut Harbor	......	....	
E. 42	Cunningham's Creek	1841	1–2,400	Lieut. I. C. Woodruff.
E. 43	Huron Harbor	1853 1854	1– 600	Captain Stansbury.
E. 44	Black River Harbor	......	1–2,400	
E. 45	Preliminary sheet from McLane's Point to Stony Point, Mich.	......	....	
E. 46	Erie Harbor, with soundings (old sheet)	......	....	
E. 46b	Erie Harbor, showing proposed works	......	....	
E. 48	Bass Islands (large roll)	1845	1–7,920	Lieut. I. C. Woodruff.
E. 49	Kelley's Island (large roll)	1846	1–7,920	Lieut. J. N. Macomb.
E. 50	Pelée Island (large roll)	1847	1–15,840	Lieut. J. W. Gunnison.
E. 51	Middle Island Shoal	1858	1–4,800	J. A. Potter and O. N. Chaffee.
E. 57	Bass Islands (Hen and Chickens)	1845?	1–5,280	
E. 58	City of Richmond and mouth of Grand River	1836	(?)	(?)
E. 60	Mouth of Detroit River and Canada shore (old sheet)	......	....	
E. 155	Chart showing points of intersection of channel reaches in Sandusky Bay.	1878	1–2,000	A. C. Lamson.

NIAGARA RIVER.

Shore-line and topography.

TOPOGRAPHICAL CHARTS—NIAGARA RIVER.

No.	Locality.	Date.	Scale.	Topographer, &c.
N. 1	From head of Niagara River to 4 miles north of same, including city and harbor of Buffalo and Fort Erie.	1875	1-10,000	F. Terry.
N. 2	From head of Strawberry Island to 3½ miles west of same, on Canada shore, including Strawberry Island.	1875	1-10,000	Do.
N. 3	From head of Grand Island to 2 miles west on Canada shore and 4 miles northeast on New York shore, including Frog Island.	1875	1-10,000	Do.
N. 4	From 1½ miles southwest of Tonawanda to 5 miles north of same, including town of Tonawanda.	1875	1-10,000	A. C. Lamson.
N. 5	From 2 miles west of head of Grand Island to 7 miles north of same, including western shore of Grand Island.	1875	1-10,000	Do.
N. 6	From 2 miles south of foot of Grand Island to 3 miles west of same, including foot of Grand Island, Navy Island, and 5 miles of New York shore.	1875	1-10,000	Do.
N. 7	From 2 miles south of Lewiston, N. Y., to Chippewa, Ontario, including Niagara Falls on scale of 1-2,500.	1875	1-10,000	F. M. Towar.
N. 8	From southern limits of Youngstown, N. Y., to 2 miles above Lewiston, N. Y., including villages of Lewiston, N. Y., and Queenstown.	1875	1-10,000	Do.

LAKE ONTARIO.

1. Shore-line and topography.
2. Off-shore hydrography.
3. Harbor and miscellaneous.

1.—TOPOGRAPHICAL CHARTS—LAKE ONTARIO.

No.	Locality.	Date.	Scale.	Topographer, &c.
O. 13	Lake Ontario, South Bay Point, Timber and False Ducks Islands.	1874	1-10,000	F. M. Towar.
O. 14	Main Duck and Yorkshire Islands	1874	1-10,000	Do.
O. 15	From Tibbitts' Point to Mud Bay, including Grenadier and Fox Islands.	1874	1-10,000	J. R. Mayer.
O. 16	From Mud Bay to the Isthmus	1874	1-10,000	Do.
O. 17	Chaumont Bay, from Long Camp to Three-Mile Bay	1874	1-10,000	Do.
O. 18	Peninsular Point, between Isthmus and Pillar Point	1874	1-10,000	Do.
O. 19	Peninsular and Pillar Point and entrance to Chaumont Bay.	1874	1-10,000	Do.
O. 20	Point Vesuvius to Pillar Point, including Griffin Bay and part of Chaumont Bay.	1874	1-10,000	Do.
O. 21	North end of Chaumont Bay and Three-Mile Bay, including village of Chaumont and Three-Mile Bay, also Catfish River.	1874	1-10,000	Do.
O. 22	From Pillar Point to middle of south shore of Henderson Bay, including Gull and Snake Islands.	1874	1-10,000	John Eisenmann.
O. 23	Black River Bay, including villages of Sacket's Harbor and Dexter, also Muscalonge Bay and mouth of Black River.	1874	1-10,000	Do.
O. 24	Western half of Henderson and Six-Town Point	1874	1-10,000	Do.
O. 25	From Stony Point to Station Gleason, also Stony Island	1874	1-10,000	Do.
O. 26	Galloo, Little Galloo, and Calf Islands, also Galloo Shoal.	1874	1-10,000	Do.
O. 27	From Stony Point to 6 miles south of same, including Drowned Island.	1874	1-10,000	Do.
O. 28	From 3 miles north of Big Sandy Creek to middle base station of primary base-line (Sandy Creek).	1874	1-10,000	F. Terry.
O. 29	From Little Sandy Creek to Grindstone Creek, east end of Lake Ontario, including Port Ontario.	1874	1-10,000	F. M. Towar.
O. 30	From Grindstone Creek to Butterfly Creek, southeast corner Lake Ontario.	1874	1-10,000	Do.
O. 31	From Butterfly Creek to Nine-Mile Point	1874	1-10,000	Do.
O. 32	From Nine-Mile Point to eastern limits of city of Oswego.	1874	1-10,000	Do.
O. 33	City of Oswego to 3 miles west of same	1874	1-10,000	J. R. Mayer.
O. 34	From 3 miles west of Oswego to 9½ miles west of same	1874	1-10,000	F. Terry.
O. 35	From 9 miles west of Oswego to Little Sodus Bay, inclusive.	1874	1-10,000	Do.
O. 36	From Little Sodus Bay to 5 miles west of same	1874	1-10,000	J. Eisenmann.
O. 37	From 5 miles west of Little Sodus Bay to East Bay, including Port Bay (and from East Bay 1½ miles westward, added in 1875).	1874	1-10,000	Do.

1.—TOPOGRAPHICAL CHARTS—Continued.

No.	Locality.	Date.	Scale.	Topographer, &c.
O. 39	Great Sodus Bay, N. Y., including village of Sodus Point, N. Y.	1875	1-10,000	Do.
O. 40	From ¾ miles east of the village of Sodus Point to 5 miles west of same.	1875	1-10,000	Do.
O. 41	From 4½ miles east of Pultneyville, N. Y., to 2½ miles west of same, including Pultneyville	1875	1-10,000	J. R. Mayer.
O. 42	From 2½ miles west of Pultneyville to 7 miles west of same (½ mile east of Smoky Point).	1875	1-10,000	Do.
O. 43	From ½ mile east of Smoky Point to ½ mile east of Lyon's Point.	1875	1-10,000	F. Terry.
O. 44	From ½ mile east of Lyon's Point to 1 mile east of Irondequoit Bay.	1875	1-10,000	Do.
O. 45	From 1 mile east of Irondequoit Bay to 1½ miles east of Genesee River, including Irondequoit Bay.	1875	1-10,000	F. M. Towar
O. 46	From 1½ miles east of Genesee River to 1½ miles west of same, including Genesee River to head of navigation.	1875	1-10,000	Do.
O. 47	From 1½ miles west of Genesee River to Long Pond, including Long Pond, Buck's Pond, and Round Pond.	1875	1-10,000	Do.
O. 48	From 2½ miles east of Braddock's Point to 6 miles west of same, including Braddock's Bay.	1875	1-10,000	A. C. Lamson
O. 49	From 6 miles west of Braddock's Point to 2 miles west of Sandy Creek.	1875	1-10,000	Do.
O 50	From 2 miles west of Sandy Creek to 8 miles west of same, including Devil's Nose.	1875	1-10,000	Do.
O. 51	From ½ mile east of Oak Orchard Creek to 8 miles east of same.	1875	1-10,000	F. Terry.
O. 52	From ½ mile east of Oak Orchard Creek to 7 miles west of same.	1875	1-10,000	Do.
O. 53	From ½ mile east of county line (Orleans County) to 6½ miles east of Terry's Quit-post.	1875	1-10,000	J. R. Mayer.
O. 54	From ½ mile east of County-Line P. O. to 6 miles west of same to Lamson's Quit-post, including Thirty-Mile Point.	1875	1-10,000	Do.
O. 55	From 1 mile east of Olcott, N. Y., to 7½ miles east of same.	1875	1-10,000	A. C. Lamson.
O. 56	From Olcott, N. Y., to Wilson, N. Y., 6 miles west of Olcott, N. Y.	1875	1-10,000	Do.
O. 57	From Wilson's Piers, N. Y., to a point 8 miles east of Niagara River.	1875	1-10,000	John Eisenmann.
O. 58	From 8 miles east of Niagara River to 4½ miles east of same.	1875	1-10,000	Do.
O. 59	From 4½ miles east of mouth of Niagara River to 3 miles west of same, including villages of Niagara and Youngstown.	1875	1-10,000	F. M. Towar.
O. 60	From 3 milss west of mouth of Niagara River to 6 miles west of same.	1875	1-10,000	Do.
O. 61	From Port Dalhousie, Ontario, to 5 miles east of same.	1875	1-10,000	J. Eisenmann.
O. 62	From Port Dalhousie, mouth of Welland Canal, to 6 miles west of same, including village of Dalhousie.	1875	1-10,000	Do.
O. 63	South Bay, Prince Edward's County, Ontario, showing topography around station Vanderlip (field-sketch attached).	1875	1-10,000	Thomas Russell.

2.—HYDROGRAPHICAL CHARTS—LAKE ONTARIO.

No.	Locality.	Date.	Scale.	Hydrographer, &c.
O. A.	Off-shore hydrography, northeast part of Lake Ontario, between Amherst, Simcoe, Real Duck Islands, and Traverse Point.	1874	1-40,000	Lieut. T. N. Bailey.
O. B.	Off-shore hydrography, northeast part of Lake Ontario, between Long Island, Real Duck Island, and Stony Point.	1874	1-40,000	Do.
O. C.	Off-shore hydrography between Galloo Island, Stony Point, and Oswego.	1874	1-60,000	Do.
O. D.	Off-shore hydrography, William and Harris Shoals ...	1874	1-10,000	Do.
O. E.	Off-shore hydrography, Lake Ontario, Big Bar Shoal..	1874	1-10,000	Do.
O. F.	Off-shore hydrography, Lake Ontario, Charity Shoal .	1874	1- 3,000	Do.
O. G.	Off-shore hydrography, Lake Ontario, vicinity of Pigeon River	1874	1- 4,000	Do.
O. H.	Off-shore hydrography, from Galloo Island west to South Bay Point	1875	1-60,000	Capt. H. M. Adams.
O. I.	Off-shore hydrography, from Oswego [illegible] Bald..	1875	1-60,000	Lieut. C. F. Powell.
O. J.	From Sandy Creek to [illegible] Ontario. ..	1875	1-60,000	Capt. H. M. Adams.
O. L.	Off-shore hydrography [illegible] Pultney-ville	1875	1-60,000	Lieut. C. F. Powell.
O. M.	From Sandy Creek to Olcott, N. Y.	1875	1-60,000	Do.
O. N.	From Olcott to [illegible] west of Port Dalhousie.......	1875	1-60,000	Do.

3.—HARBOR AND MISCELLANEOUS CHARTS—LAKE ONTARIO.

No.	Locality.	Date.	Scale.	Topographer, &c.
O. 1	Lake Ontario	1830		August Ford, U. S. N.
O. 2	Chart of Lake Ontario, with harbors and ports	1869		Capt. Owen, R. N.
O. 7	Chart of Niagara	1819		Bird and Thompson.
O. 8	Village of Black Rock			W. A. Bird.

SAINT LAWRENCE RIVER.

Shore-line and topography.

TOPOGRAPHICAL CHARTS—SAINT LAWRENCE RIVER.

No.	Locality.	Date.	Scale.	Topographer, &c.
St. L. 1	From St. Regis Island to Massena Point	1871	1-10,000	A. C. Lamson.
St. L. 2	From Massena Point to Dickinson's Landing, including Barnhart's, Shieck's, and part of Long Sault Islands.	1871	1-10,000	F. M. Towar.
St. L. 3	From west end of Long Sault Island to 2 miles west of Aultsville, including Delany's Crails and Chat Islands and town of Aultsville.	1871	1-10,000	A. C. Lamson and F. M. Towar.
St. L. 4	From 2 miles west of Aultsville to Morrisburg, including Chrisler's, Gooseneck, and Murphy's Islands.	1871 1871	1-10,000 1-10,000	Do. F. M. Towar.
St. L. 5	From Morrisburg to Matilda, including McKean's and Ogden's Islands, Waddington, N. Y., and the upper end of Morrisburg Canal.	1871	1-10,000	Do.
St. L. 6	From Matilda to Isle au Galop, including Point Rockaway, Point Iroquois, and the Galop Canal.	1871	1-10,000	Do.
St. L. 7	From Isle au Galop to 5 miles west of same	1871	1-10,000	Do.
St. L. 8	From 5 miles west of Isle au Galop to 6 miles west of Ogdensburg and Prescott.	1871	1-10,000	A. C. Lamson and F. M. Towar.
St. L. 9	From 6 miles west of Ogdensburg to Brockville, including Brockville, Maitland, Morristown, and McNair's Island.	1871	1-10,000	A. C. Lamson.
St. L. 9½	Final plot of soundings in North Sault Rapids	1871 1872		Capt. W. R. Livermore.
St. L. 10	Brockville to Oak Point	1872	1-10,000	A. C. Lamson.
St. L. 11	Oak Point to upper end of Oak Island	1872	1-10,000	F. M. Towar.
St. L. 12	Grenadier Island, with adjoining New York and Canada shore.	1872	1-10,000	Do.
St. L. 13	From south end of Grenadier Island to north end of Hill Island, including Ant Island and Goose Bay, N. Y.	1872	1-10,000	Do.
St. L. 14	North end of Wellesley Islands and Hill Island, and New York shore from Excelsior Group Islands to 1 mile south of Alexander Bay.	1872	1-10,000	A. C. Lamson.
St. L. 15	Main part of Wellesley Island and New York shore.	1872	1-10,000	Do.
St. L. 19	From Manson's Point to 1 mile above Clayton, including lower half of Grindstone Island.	1873	1-10,000	J. R. Mayer.
St. L. 20	From 1 mile above Clayton to foot of Long Island, including upper half of Grindstone Island.	1873	1-10,000	Do.
St. L. 21	From foot of Long Island to foot of Carleton Island.	1873	1-10,000	F. M. Towar.
St. L. 22	Carleton Island and adjoining shores	1873	1-10,000	Do.
St. L. 23	From 2 miles east of Cape Vincent to Tibbett's Point, including Cape Vincent.	1873	1-10,000	Do.
St. L. 24	From Rockport to head of Wellesley Island	1873	1-10,000	Do.
St. L. 25	From head of Wellesley Island to Gananoque	1873	1-10,000	Do.
St. L. 26	North side of Long Island, from foot to Oak Point.	1873	1-10,000	Henry Custer.
St. L. 27	Southwest portion of Howe Island	1873	1-10,000	Do.
St. L. 28	Vicinity of Gananoque and part of foot of Howe Island.	1874	1-10,000	F. M. Towar.
St. L. 28½	Soundings in vicinity of Gananoque	1873	1-10,000	Capt. W. R. Livermore.
St. L. 29	Foot of Howe Island, with adjacent Canada shore.	1874	1-10,000	F. M. Towar.
St. L. 30	Head of Howe Island, with adjacent Canada shore.	1874	1-10,000	Do.
St. L. 31	North shore of Long Island, from head of Howe Island to above Brown's Point, and adjacent Canada shore.	1874	1-10,000	F. Terry.
St. L. 32	North shore of Long Island, from above Brown's Point to foot of Simcoe Island, with adjacent Canada shore, including Kingston.	1874	1-10,000	Do.
St. L. 33	Simcoe Island, with adjacent Canada shore	1874	1-10,000	Do.
St. L. 34	Head of Wolfe Island, from Simcoe Island to Long Point, including Horse-shoe Island.	1874	1-10,000	Do.
St. L. 35	Head of Long Island, from Long Point to Bear Point.	1874	1-10,000	Do.
St. L. 36	Long Island, from Bear Point to Tibbett's Point	1874	1-10,000	J. R. Mayer.
St. L. 37	Foot of Amherst Island and adjacent Canada shore, including Brother Islands.	1874	1-10,000	F. M. Towar.
St. L. 38	Southeast side of Amherst Island, including Nut Island.	1874	1-10,000	Do.

LAKE CHAMPLAIN.

Shore-line and topography.

TOPOGRAPHICAL CHARTS—LAKE CHAMPLAIN.

No.		Locality.	Date.	Scale.	Topographer, &c.
C.	1	Cumberland Bay, N, Y	1870	1-10, 000	Lieut. W. R. Livermore.
C.	2	Burlington Bay, Vt	1870	1- 5, 000	Do.
C.	4	Lake Champlain, from Whitehall to 1 mile north the Elbow.	1871	1- 2, 500	Lieut. E. Maguire.
C.	5	From 1 mile north the Elbow to 1,000 feet north of Light No. 3.	1871	1- 2, 500	Do.
C.	6	From 1,000 feet north of Light No. 3 to ½ mile north of Light No. 6.	1871	1- 2, 500	Do.
C.	7	From ½ mile north of Light No. 6 to ½ mile north the Narrows.	1871	1- 2, 500	Do.
C.	8	From ½ mile north of the Narrows to Light-house No. 11.	1871	1- 2, 500	Do.
C.	9	From Light No. 11 to 1 mile north of Bald Mountain.	1871	1- 2, 500	Do.

APPENDIX P P.

GEOGRAPHICAL AND TOPOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE ONE HUNDREDTH MERIDIAN, IN THE STATES AND TERRITORIES OF CALIFORNIA, COLORADO, KANSAS, NEBRASKA, NEVADA, OREGON, TEXAS, ARIZONA, IDAHO, MONTANA, NEW MEXICO, UTAH, WASHINGTON, AND WYOMING.

REPORT OF CAPTAIN GEORGE M. WHEELER, CORPS OF ENGINEERS, OFFICER IN CHARGE OF THE WORK, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

CONTENTS.

ILLUSTRATIONS.

REPORT.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1880.

GENERAL: I have the honor to submit the usual report for the fiscal year ending June 30, 1880.

No field work was prosecuted during the fiscal year, appropriations for office work alone being available.

SUMMARY OF OFFICE OPERATIONS.

Astronomical positions computed	5
Geodetic figures computed	14
Distances computed	504
Azimuths computed	84
Longitudes and latitudes computed	96
Sextant latitude stations computed	11
Number of main triangulation stations computed	6
Number of triangles computed	252
Number of secondary triangulation stations computed	13
Number of points fixed by cross-sights computed	15
Number of three-point stations computed	45
Cistern-barometer altitudes computed	59
Aneroid-barometer altitudes computed	995
Sheets and parts of sheets plotted (1 inch to 2 miles)	8
Special sheets drawn (various scales)	5
Atlas maps (1 inch to 4 miles) published	1
Atlas maps (1 inch to 4 miles) approaching completion for publication	5
Main triangulation sheets (1 inch to 8 miles), Nos. 7, 8, 9, 11, 12, 19, 20, and 21, projected on 5 sheets, completed	8
Tracing sheets of positions (1 inch to 3 miles) completed	10

Reports in course of publication: Vol. I.—Geographical Report; Special Geological Report, by Prof. John J. Stevenson; and Tables of geographical positions, altitudes, distances, &c.

Reports distributed	4,284
Maps distributed	13,015

The following number of reports and maps were furnished the Director of the Geological Survey:

Reports	22
Maps	72

Maps in course of preparation for publication:

Topographical atlas sheets	8
Land-classification atlas sheets	8
Geological atlas sheets	3
Total	19

Certain of the above sheets must await publication until additional field data, the result of triangulation and topographical observations, are gathered.

Lieutenant Tillman was temporarily in charge of the office until August 26, 1879, when, being relieved from duty under my orders by Special Orders No. 121, Headquarters of the Army, Adjutant-General's

Office, May 22, 1879, he proceeded to report to the Superintendent of the Military Academy, West Point, N. Y.

Lieutenant Griffin has not been on duty with the survey during the fiscal year. He was detached by paragraph 9 of Special Orders No. 154, Headquarters of the Army, Adjutant-General's Office, July 1, 1879, and ordered to report to the commanding general Division of the Atlantic for temporary duty. By paragraph 4, Special Orders No. 34, Headquarters of the Army, Adjutant-General's Office, February 12, 1880, he was relieved from duty under my orders and directed to report to the commanding officer Battalion of Engineers at Willets Point for duty.

Lieutenant Young was engaged at the Ogden office until July 19, 1879, when, in pursuance of orders received from the president of the Engineer Examining Board in New York City, he proceeded to that point to appear for examination. He was granted leave of absence for one month by the Chief of Engineers, per Special Orders No. 85, Headquarters Corps of Engineers, July 29, 1879; and, by virtue of paragraph 2, Special Orders No. 121, Headquarters of the Army, Adjutant-General's Office, May 22, 1879, he was relieved from duty under my orders, to proceed to West Point to report to the Superintendent of the Military Academy for duty.

Lieutenant Macomb has been on duty with the survey during the entire year, engaged upon triangulation and topographical office reductions, and in charge of the topographical drawing room.

ASTRONOMICAL.

The discussions of the longitudes of the stations occupied in 1878 at Walla Walla, Wash., and Fresno, Cal., omitted in the annual report of 1879, are here introduced, and complete the reports upon the five main stations at which astronomical observations of that year were conducted.

Tabulation of stars used for determination of time at Ogden, Utah, and Fresno, Cal.

Name of star.	Ogden.				Fresno.			
	Oct. 5.	Oct. 6.	Oct. 7.	Oct. 8.	Oct. 5.	Oct. 6.	Oct. 7.	Oct. 8.
δ Draconis						1		1
Gr. 1308, S. P								1
δ Aquilæ					1	1		
β Cygni					1	1	1	1
9 Cygni	1							
κ Aquilæ					1	1	1	
o Cygni	1							1
φ Cygni	1							
28 Heis Cygni	1							
γ Aquilæ					1	1	1	1
δ Sagittæ	1							
α Aquilæ					1	1	1	
12 Vulpeculæ	1							
ε Draconis	1		1		1	1	1	1
γ Sagittæ			1				1	1
τ Aquilæ					1	1		1
15 Vulpeculæ		1	1					
η H. Sagittæ		1	1					
3 H. Ursæ Majoris							1	
θ Sagittæ		1	1	1				
θ Aquilæ					1	1	1	1
ζ Aquilæ	1	1	1					
a^2 Capricornis						1	1	
κ Cephei	1	1	1		1			1

Ogden, Utah, October 6, 1878; after signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
226 Cephei B	W.	22 32 29.63	− 0.23	− 0.83	− 0.76	22 32 27.81	22 30 11.10	− 2 16.71
10 Lacertæ	W.	22 36 07.90	− 0.09	+ 0.02	− 0.24	22 36 07.59	22 33 50.93	2 16.66
η Pegasi	W.	22 39 37.67	− 0.08	+ 0.08	− 0.22	22 39 37.45	22 37 20.87	2 16.58
λ Pegasi	W.	22 42 59.98	− 0.07	+ 0.12	− 0.21	22 42 59.82	22 40 43.16	2 16.66
μ Pegasi	W.	22 46 27.61	− 0.07	+ 0.12	− 0.21	22 46 27.45	22 44 10.76	2 16.69
π Cephei	E.	23 06 22.79	− 0.19	0.76	+ 0.72	23 06 22.56	23 04 05.69	2 16.87
τ Pegasi	E.	23 16 56.35	− 0.06	+ 0.12	+ 0.21	23 16 56.62	23 14 40.02	2 16.60
υ Pegasi	E.	23 21 37.89	− 0.06	+ 0.13	+ 0.21	23 21 38.17	23 19 21.55	2 16.62
70 Pegasi	E.	23 25 19.70	0.05	+ 0.14	+ 0.19	23 25 19.98	23 23 03.26	2 16.72
72 Pegasi	E.	23 30 14.65	− 0.07	+ 0.08	+ 0.22	23 30 14.88	23 27 58.21	2 16.67
γ Cephei	E.	23 36 43.61	− 0.21	− 0.94	+ 0.84	23 36 43.30	23 34 26.87	− 2 16.43

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 16^s.66\ .\ \text{for } 23^h.0$

$$\begin{aligned}
0 &= +0^s.038 + 8.21\,d\Delta T + 0.76\,da + 0.78\,dc \\
0 &= +0.132 + 0.76\,d\Delta T + 4.25\,da - 1.65\,dc \\
0 &= +0.151 + 0.78\,d\Delta T - 1.65\,da + 20.28\,dc
\end{aligned}$$

$$\begin{aligned}
d\Delta T &= 0^s.000 & \Delta T &= -2^m\ 16^s.660 & (\text{wt.} &= 8.02) \\
da &= -0.035 & a &= +0.365 & (\text{wt.} &= 4.03) \\
dc &= -0.010 & c &= +0.190 & (\text{wt.} &= 19.51)
\end{aligned}$$

Ogden, Utah, October 7, 1878; before signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	R.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
ε Draconis	E.	19 50 50.04	− 0.11	− 0.59	+ 0.68	19 50 50.02	19 48 34.67	− 2 15.35
γ Sagittæ	E.	19 55 37.88	− 0.04	+ 0.17	+ 0.25	19 55 38.26	19 53 22.80	2 15.46
15 Vulpeculæ	E.	19 58 22.26	− 0.05	+ 0.11	+ 0.26	19 58 22.58	19 56 07.23	2 15.35
η Sagittæ	E.	20 02 02.74	− 0.04	+ 0.16	+ 0.25	20 02 03.11	19 59 47.77	2 15.34
θ Sagittæ	E.	20 06 51.51	− 0.04	+ 0.16	+ 0.25	20 06 51.88	20 04 36.66	2 15.22
G Aquilæ	E.	20 10 55.95	− 0.04	+ 0.19	+ 0.24	20 10 56.34	20 08 40.99	2 15.35
κ Cephei	E.	20 15 12.07	− 0.15	− 1.13	+ 1.07	20 15 11.86	20 12 56.70	2 15.16
ε Cygni	W.	20 43 35.08	− 0.15	+ 0.07	− 0.28	20 43 34.72	20 41 19.40	2 15.32
Pi. XX 358	W.	20 48 36.24	− 0.14	+ 0.11	− 0.26	20 48 35.95	20 46 20.49	2 15.46
32 Vulpeculæ	W.	20 51 40.25	− 0.14	+ 0.11	− 0.26	20 51 39.96	20 49 24.73	2 15.23
Br. 2740	W.	20 55 22.20	− 0.58	− 1.53	− 1.36	20 58 18.73	20 5[illegible] 03.21	2 15.52
ζ Cygni	W.	21 10 03.38	− 0.15	+ 0.10	− 0.27	21 10 03.06	21 07 47.87	− 2 15.19

NORMAL EQUATIONS.

$a_0 = +\ 0^s.40 \qquad c_0 = +\ 0^s.20 \qquad \Delta T_0 = -\ 2^m\ 15^s.32 \qquad \text{for } 20^h.5$

$$0 = -\ 0^s.071 + 9.22\ d\Delta T + 1.27\ da + 2.10\ dc$$
$$0 = -\ 0.074 + 1.27\ d\Delta T + 4.49\ da - 0.25\ dc$$
$$0 = -\ 0.708 + 2.10\ d\Delta T - 0.25\ da + 21.26\ dc$$

$$d\Delta T = -\ 0^s.003 \qquad \Delta T = -\ 2^m\ 15^s.323 \quad (\text{wt.} = 8.64)$$
$$da = +\ 0.019 \qquad a = +\ 0.419 \quad (\text{wt.} = 4.30)$$
$$dc = +\ 0.034 \qquad c = +\ 0.234 \quad (\text{wt.} = 20.71)$$

Ogden, Utah, October 7, 1878; after signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	Æ.	Δ T.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
10 Lacertæ	W.	22 36 6.32	− 0.12	+ 0.03	− 0.23	22 36 06.00	22 33 50.92	− 2 15.08
η Pegasi	W.	22 39 36.32	− 0.11	+ 0.10	− 0.21	22 39 36.10	22 37 20.87	2 15.23
λ Pegasi	W.	22 42 58.67	− 0.10	+ 0.15	− 0.20	22 42 58.52	22 40 43.16	2 15.36
ι Cephei	W.	22 47 40.50	− 0.21	− 0.45	− 0.44	22 47 39.40	22 45 24.12	2 15.28
β Pegasi	E.	23 0 10.49	− 0.06	+ 0.12	+ 0.21	23 00 10.76	22 57 55.58	2 15.18
56 Pegasi	E.	23 3 29.19	− 0.06	+ 0.14	+ 0.20	23 03 29.47	23 01 14.26	2 15.21
Pi. XXIII. 4	E.	23 6 58.03	− 0.06	+ 0.19	+ 0.19	23 06 58.35	23 04 43.07	2 15.28
o Cephei	E.	23 15 57.03	− 0.14	− 0.51	+ 0.48	23 15 56.86	23 13 41.59	− 2 15.27

NORMAL EQUATIONS.

$a_0 = +0^s.40.$ $c_0 = +0^s.20$ $\Delta T_0 = -2^m\ 15^s.23$ for $23^h.0$

$$0 = -0.021 + 6.53\, d\Delta T + 0.61\, da - 0.11 dc$$
$$0 = -0.071 + 0.61\, d\Delta T + 1.54\, da + 0.24 dc$$
$$0 = +0.205 - 0.11\, d\Delta T + 0.24\, da + 12.87 dc$$

s.		
$d\Delta T = -0.002$	$\Delta T =$	(wt. = 6.29)
$da = +0.049$	$a = +0.449$	(wt. = 1.48)
$dc = -0.017$	$c = +0.183$	(wt. = 12.83)

Ogden, Utah, October 8, 1878; before signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
θ Sagittæ	E.	20 06 50.20	− 0.05	+ 0.16	+ 0.20	20 06 50.51	20 04 36.64	− 2 13.87
39 Cygni	E.	20 21 15.47	− 0.05	+ 0.08	+ 0.22	29 21 15.72	20 19 02.03	2 13.69
41 Cygni	E.	20 26 40.98	− 0.05	+ 0.10	+ 0.22	20 26 41.25	20 24 27.47	2 13.78
ε Delphini	E.	20 29 39.99	− 0.04	+ 0.22	+ 0.19	20 29 40.36	20 27 26.31	2 14.05
73 Draconis	E.	20 35 20.16	− 0.14	− 0.89	+ 0.71	20 35 19.84	20 33 05.85	2 13.89
Br. 2749	W.	20 55 20.15	− 0.45	− 1.57	− 1.10	20 55 17.03	20 53 03.15	2 13.88
61 Cygni	W.	21 03 43.02	− 0.13	+ 0.03	− 0.24	21 03 42.68	21 01 28.84	2 13.84
ζ Cygni	W.	21 10 01.78	− 0.11	+ 0.10	− 0.22	21 10 01.55	21 07 47.86	2 13.69
ν Cygni	W.	21 15 11.32	− 0.12	+ 0.06	− 0.23	21 15 11.03	21 12 57.20	2 13.83
1 Pegasi	W.	21 18 44.12	− 0.10	+ 0.17	− 0.20	21 18 43.99	21 16 30.03	2 13.96
β Cephei	W.	21 29 22.14	− 0.26	− 0.61	− 0.55	21 29 20.72	21 27 06.79	− 2 13.93

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m.13^s.84 \qquad$ for $20^h.8$

$$\begin{aligned}
&\quad s.\\
0 &= +0.060 + 8.22\,d\Delta T + 0.60\,da - 0.93\,dc\\
0 &= -0.091 + 0.60\,d\Delta T + 4.03\,da + 2.52\,dc\\
0 &= +0.132 - 0.93\,d\Delta T + 2.52\,da + 20.26\,dc
\end{aligned}$$

$$\begin{array}{rlrl}
 & s. & & m.\ \ s. \\
d\Delta T = & -0.010 & \Delta T = & -2\ 13.850 \quad (\text{wt.} = 8.32)\\
da = & +0.031 & a = & +\ \ 0.431 \quad (\text{wt.} = 3.66)\\
dc = & -0.011 & c = & +\ \ 0.189 \quad (\text{wt.} = 18.48)
\end{array}$$

Ogden, Utah, October 8, 1878; after signals.

Name of star.	Clamp.	T.			bB.	aA.	cC.	T′.			Æ.			ΔT.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
ι Cephei	W.	22	47	38.65	− 0.12	− 0.40	− 0.45	22	47	37.68	22	45	24.10	− 2	13.58
β Pegasi	W.	23	00	09.43	− 0.06	+ 0.11	− 0.21	23	00	09.27	22	57	55.57	2	13.70
56 Pegasi	W.	23	03	28.17	− 0.06	+ 0.12	− 0.20	23	03	28.03	23	01	14.25	2	13.78
Pi. XXIII, 4	W.	23	06	56.80	− 0.05	+ 0.17	− 0.19	23	06	56.73	23	04	43.07	2	13.66
ο Cephei	E.	23	15	55.34	− 0.01	− 0.46	+ 0.48	23	15	55.35	23	13	41.57	2	13.78
υ Pegasi	E.	23	21	34.88	− 0.01	+ 0.14	+ 0.20	23	21	35.21	23	19	21.54	2	13.67
72 Pegasi	E.	23	30	11.48	− 0.01	+ 0.09	+ 0.22	23	30	11.78	23	27	58.20	− 2	13.58

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m.\ 13^s.66 \qquad \text{for } 23^h.2$

$$
\begin{aligned}
& \quad\ \ s. \\
0 &= +0.076 + 5.65\,d\Delta T + 0.54\,da - 1.03\,dc \\
0 &= -0.003 + 0.54\,d\Delta T + 1.53\,da - 0.61\,dc \\
0 &= +0.153 - 1.03\,d\Delta T - 0.61\,da + 11.57\,dc
\end{aligned}
$$

$$
\begin{array}{rlrl}
 & s. & & m.\ \ s. \\
d\Delta T = & -0.016 & \Delta T = & -2\ 13.676 \quad (\text{wt.} = 5.40) \\
da = & +0.008 & a = & +\ \ \ 0.402 \quad (\text{wt.} = 1.46) \\
dc = & -0.015 & c = & +\ \ \ 0.185 \quad (\text{wt.} = 11.10)
\end{array}
$$

Fresno, Cal., October 5, 1878; before signals.

Name of star.	Clamp.	T.	b B.	a A.	c C.	T′.	Æ.	Δ T.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
δ Aquilæ	W.	19 18 13.06	0.00*	+ 24.41	+ 4.22	19 18 41.69	19 19 24.00	+ 42.31
β Cygni	W.	19 24 55.45	....	+ 7.75	+ 4.76	·19 25 07.96	19 25 50.64	42.68
κ Aquilæ	W.	19 29 05.95	....	+ 30.67	+ 4.25	19 29 40.87	19 30 23.12	42.25
γ Aquilæ	W.	19 39 24.25	....	+ 19.79	+ 4.28	19 39 48.32	19 40 30.67	42.35
α Aquilæ	W.	19 43 45.27	....	+ 20.90	+ 4.26	19 44 10.43	19 44 53.03	42.60
ε Draconis	W.	19 48 49.84	....	− 70.04	+ 12.20	19 47 52.09	19 48 34.83	42.74
ζ Aquilæ	E.	19 57 13.86	....	+ 21.91	− 4.24	19 57 31.53	19 58 14.11	42.58
θ Aquilæ	E.	20 03 58.84	....	+ 26.90	− 4.21	20 04 21.53	20 05 04.07	42.54
κ Cephei	E.	20 13 44.42	....	−130.19	− 19.24	20 11 14.99	20 12 56.89	41.90
ε Delphini	E.	20 26 28.78	....	+ 19.42	− 4.29	20 26 43.91	20 27 26.40	42.49
α Cygni	E.	20 36 51.06	....	− 8.73	− 5.94	20 36 36.39	20 37 18.97	42.58
ε Cygni	E.	20 40 38.88	....	+ 2.93	− 5.05	20 40 36.76	20 41 19.45	+ 42.69

* At this station the transit level failed to work, as its bubble was too long. The instrument was carefully adjusted for each group by the zenith-telescope level; so that b is counted zero throughout.

NORMAL EQUATIONS.

$a_0 = +43^s.8 \qquad c_0 = -4^s.2 \qquad \Delta T_0 = +42^s.50$

$$
\begin{aligned}
0 &= +0^s.079 + 10.10\, d\Delta T + 2.81\, da + 0.14\, dc \\
0 &= +0.086 + 2.81\, d\Delta T + 4.45\, da - 2.05\, dc \\
0 &= +0.157 + 0.14\, d\Delta T - 2.05\, da + 17.45\, dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T &= -0^s.000 \quad \text{wt.} = 8.19 & \Delta T &= +42^s.500 \text{ (for } 19^h.9) \\
da &= -0.025 \quad \text{wt.} = 3.42 & a &= +43.775 \\
dc &= -0.012 \quad \text{wt.} = 16.26 & c &= -4.212
\end{aligned}
$$

Fresno, Cal., October 5, 1878; after signals.

Name of star.	Clamp.	T.	b B.	a A.	c C.	T′.	Æ.	Δ T.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
θ Aquarii	E.	22 09 18.16	0.00	+ 31.42	− 4.21	22 09 45.37	22 10 27.86	+ 42.49
π Aquarii	E.	22 18 02.57	....	+ 25.76	− 4.16	22 18 24.17	22 19 06.86	42.69
η Aquarii	E.	22 28 04.31	....	+ 26.68	− 4.16	22 28 26.83	22 29 09.34	42.51
ζ Pegasi	E.	22 34 28.39	....	+ 19.91	− 4.23	22 34 44.07	22 35 26.66	42.59
ι Cephei	E.	22 45 42.98	....	− 51.16	10.06	22 44 44.76	22 45 24.24	42.48
α Pegasi	W.	22 57 41.22	....	+ 17.10	+ 4.30	22 58 02.62	22 58 45.10	42.48
o Cephei	W.	23 13 46.59	....	− 58.46	+ 10.85	23 12 58.98	23 13 41.61	42.63
θ Piscium	W.	23 20 41.54	....	+ 22.71	+ 4.18	23 21 08.43	23 21 50.97	42.54
ι Piscium	W.	23 32 34.86	....	+ 23.17	+ 4.18	23 33 02.21	23 33 44.78	+ 42.57

NORMAL EQUATIONS.

$a_0 = +\,43^s.8 \qquad c_0 = -\,4^s.7 \qquad \Delta T_0 = +\,42^s.55$ for $22^h.8$

$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$

$d\Delta T = +\,0^s.001$	$\Delta T = +\,42^s.551$	(wt. = 5.83)
$da = +\,0.064$	$a = +\,43.864$	(wt. = 2.57)
$dc = +\,0.038$	$c = -\,4.162$	(wt. = 12.44)

Fresno, Cal., October 6, 1878; before signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T'.		ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
δ Draconis	E.	19 12 21.26	0.00	− 33.90	+ 0.39	19 11 47.75	19 12 31.27	+ 43.52
δ Aquilæ	E.	19 18 26.16	....	+ 14.19	+ 0.15	19 18 40.50	19 19 23.98	43.48
β Cygni	E.	19 25 02.48	....	+ 4.50	+ 0.17	19 25 07.15	19 25 50.62	43.47
κ Aquilæ	E.	19 29 21.72	....	+ 17.83	+ 0.15	19 29 39.70	19 30 23.11	43.41
γ Aquilæ	W.	19 39 35.90	....	+ 11.50	− 0.15	19 39 47.25	19 40 30.65	43.40
α Aquilæ	W.	19 43 57.36	....	+ 12.15	0.15	19 44 09.36	19 44 53.02	43.66
ε Draconis	W.	19 48 32.48	....	− 40.71	− 0.44	19 47 51.33	19 48 34.77	43.44
ε Aquilæ	W.	19 57 18.04	....	+ 12.74	− 0.15	19 57 30.63	19 58 14.09	43.46
θ Aquilæ	W.	20 04 05.20	....	+ 15.64	− 0.15	20 04 20.69	20 05 04.05	43.36
α^2 Capricornis	W.	20 10 17.62	....	+ 19.90	− 0.15	20 10 37.37	20 11 20.90	43.53
γ Cygni	W.	20 17 12.12	....	− 1.82	− 0.20	20 17 10.10	20 17 53.55	+ 43.45

NORMAL EQUATIONS.

$a_0 = +25^s.5 \quad c_0 = 0^s.2 \qquad \Delta T_0 = +43^s.45$ for $19^h.7$

s.			
0 =	$d\Delta T$	da	dc
0 =	$d\Delta T$	da	dc
0 =	$d\Delta T$	da	dc

s.	s.	
$d\Delta T = +0.019$	$\Delta T = +43.469$	(wt. = 6.92)
$da = -0.050$	$a = +25.450$	(wt. = 3.21)
$dc = -0.050$	$c = +0.150$	(wt. = 14.63)

Fresno, Cal., October 6, 1878; after signals.

Name of star.	Clamp.	T.			$bB.$	$aA.$	$cC.$	T′.			Æ.			ΔT.
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
α Aquarii	W.	21	58	36.02	0.00	+15.65	−0.15	21	58	51.52	21	59	35.05	+43.53
θ Aquarii	W.	22	09	26.38	....	+18.35	−0.15	22	09	44.58	22	10	27.94	43.36
π Aquarii	W.	22	18	08.74	....	+15.05	−0.15	22	18	23.64	22	19	06.85	43.21
η Aquarii	W.	22	28	10.42	....	+15.59	−0.15	22	28	25.86	22	29	09.33	43.47
ς Pegasi	W.	22	34	31.84	....	+11.62	−0.15	22	34	43.31	22	35	26.65	43.34
ι Cephei	W.	22	45	10.92	....	−29.88	−0.36	22	44	40.68	22	45	24.21	43.53
α Piscis Austr	W.	22	49	48.70	....	+27.31	−0.17	22	50	15.84	22	50	59.20	43.36
α Pegasi	E.	22	57	51.32	....	+9.99	+0.15	22	58	01.46	22	58	45.10	43.64
Bradl. 3077	E.	23	07	01.12	....	−15.71	+0.27	23	06	45.68	23	07	29.04	43.36
o Cephei	E.	23	13	32.12	....	−34.15	+0.39	23	12	58.36	23	13	41.60	43.24
υ Pegasi	E.	23	18	31.20	....	+6.71	+0.16	23	18	38.07	23	19	21.55	43.48
Piscium	E.	23	20	54.13	....	+13.26	+0.15	23	21	07.54	23	21	50.97	43.43
72 Pegasi	E.	23	27	11.58	....	+3.15	+0.17	23	27	14.90	23	27	58.24	43.34
ι Piscium	E.	23	32	47.78	....	+13.54	+0.15	23	33	01.47	23	33	44.78	+43.31

NORMAL EQUATIONS.

$a_0 = +25^s.5 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = +43^s.40$ for $22^h.8$

$$0 = \quad d\Delta T \quad da \quad dc$$
$$0 = \quad d\Delta T \quad da \quad dc$$
$$0 = \quad d\Delta T \quad da \quad dc$$

$d\Delta T = +0^s.001 \qquad \Delta T = +43^s.401$ (wt. = 8.40)
$da = +0.126 \qquad a = +25.626$ (wt. = 3.26)
$dc = +0.052 \qquad c = +0.148$ (wt. = 16.42)

Fresno, Cal., October 7, 1878; before signals.

Name of star.	Clamp.	T.	b B.	a A.	c C.	T′.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
β Cygni	W.	19 25 05.35	0.00	+ 1.18	− 0.19	19 25 06.34	19 25 50.60	+ 44.26
κ Aquilæ	W.	19 29 34.49		+ 4.66	− 0.17	19 29 38.98	19 30 23.09	44.11
γ Aquilæ	W.	19 39 43.89		+ 3.01	− 0.17	19 39 46.73	19 40 30.63	43.90
α Aquilæ	W.	19 44 05.91		+ 3.17	− 0.17	19 44 08.91	19 44 53.00	44.09
ε Draconis	W.	19 48 01.48		−10.64	− 0.49	19 47 50.35	19 48 34.71	44.36
γ Sagittæ	W.	19 52 36.66		+ 2.12	− 0.18	19 52 38.60	19 53 22.82	44.22
3 H. Ursæ majoris	E.	19 59 43.19		+17.73	− 0.47	20 00 00.45	20 00 44.92	44.47
ϑ Aquilæ	E.	20 04 15.58		+ 4.09	+ 0.17	20 04 19.84	20 05 04.04	44.20
α^2 Capricornis	E.	20 10 31.26		+ 5.20	+ 0.17	20 10 36.63	20 11 20.89	44.26
γ Cygni	E.	20 17 09.59		− 0.48	+ 0.22	20 17 09.33	20 17 53.53	44.20
ε Delphini	E.	20 26 39.21		+ 2.95	+ 0.17	20 26 42.33	20 27 26.37	44.04
α Cygni	E.	20 36 35.75		− 1.33	+ 0.24	20 36 34.66	20 37 18.93	+ 44.27

NORMAL EQUATIONS.

$a_0 = +6^s.8 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = +44^s.2$ for $20^h.0$

$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$

$d\Delta T = -0.033$	$\Delta T = +44^s.167$	(wt. = 6.98)
$da = -0.151$	$a = +6.649$	(wt. = 3.56)
$dc = -0.032$	$c = +0.168$	(wt. = 15.93)

Fresno, Cal., October 7, 1878; after signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T'.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
ζ Cephei	E.	22 06 00.31	0.00	− 4.52	+ 0.59	22 05 56.38	22 06 40.57	+ 44.19
θ Aquarii	E.	22 09 38.69		+ 4.87	+ 0.32	22 09 43.88	22 10 27.93	44.05
γ Aquarii	E.	22 14 36.67		+ 4.26	+ 0.32	22 14 41.25	22 15 25.36	44.11
π Aquarii	E.	22 18 18.05		+ 3.99	+ 0.32	22 18 22.36	22 19 06.84	44.48
δ Cephei	E.	22 24 01.96		− 4.59	+ 0.60	22 23 57.97	22 24 42.06	44.09
η Aquarii	E.	22 28 20.98		+ 4.14	+ 0.32	22 28 25.44	22 29 09.32	43.88
ζ Pegasi	W.	22 34 39.88		+ 3.09	− 0.32	22 34 42.65	22 35 26.65	44.00
ι Cephei	W.	22 44 48.70		− 7.93	− 0.77	22 44 40.00	22 45 24.19	44.19
α Piscis Austr.	W.	22 50 08.10		+ 7.25	− 0.37	22 50 14.98	22 50 59.19	44.21
α Pegasi	W.	22 57 58.61		+ 2.65	− 0.33	22 58 00.93	22 58 45.09	44.16
Bradl. 3077	W.	23 06 49.63		− 4.17	− 0.57	23 06 44.89	23 07 29.04	44.15
o Cephei	W.	23 14 07.43		− 9.06	− 0.83	23 13 57.54	23 13 41.58	+ 44.04

NORMAL EQUATIONS.

$a^0 = +6^s.8$ $\quad c^0 = +0^s.2$ $\quad \Delta T^0 = +44^s.1$ for $22^h.6$.

$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$
$0 = \quad d\Delta T \quad da \quad dc$

$d\Delta T = +0^s.022$	$\Delta T = +44^s.122$	(wt. = 8.59)
$da = 0.000$	$a = +6.800$	(wt. = 4.45)
$dc = +0.117$	$c = +0.317$	(wt. = 17.89)

Fresno, Cal., October 8, 1878; before signals.

Name of star.	Clamp.	T.	*b* B.	*a* A.	*c* C.	T′.	Æ.	Δ T.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
δ Draconis	W.	19 11 44.09	0.00	+ 2.91	− 0.57	19 11 46.43	19 12 31.15	+ 44.72
Gr. 1308, Sp	W.	19 17 37.75	....	− 5.79	+ 0.61	19 17 32.57	19 18 16.87	44.30
β Cygni	W.	19 25 06.48	....	− 0.39	− 0.25	19 25 05.84	19 25 50.58	44.74
θ Cygni	W.	19 32 26.60	....	+ 0.78	− 0.34	19 32 27.04	19 33 11.85	44.81
γ Aquilæ	W.	19 39 47.02	....	− 0.99	− 0.22	19 39 45.81	19 40 30.62	44.81
ε Draconis	W.	19 47 47.14	....	+ 3.49	− 0.64	19 47 49.99	19 48 34.64	44.65
γ Sagittæ	W.	19 52 30.02	....	− 0.70	− 0.23	19 52 38.09	19 53 22.80	44.71
ζ Aquilæ	E.	19 57 30.16	....	− 1.09	+ 0.22	19 57 29.29	19 58 14.06	44.77
θ Aquilæ	E.	20 04 20.36	....	− 1.34	+ 0.22	20 04 19.24	20 05 04.02	44.78
κ Cephei	E.	20 12 04.52	....	+ 6.49	+ 1.00	20 12 12.01	20 12 56.50	44.58
π Capricorni	E.	20 19 40.93	....	− 1.89	+ 0.23	20 19 39.27	20 20 24.24	44.97
ε Delphini	E.	20 26 42.19	....	− 0.97	+ 0.22	20 26 41.44	20 27 26.36	+ 44.92

NORMAL EQUATIONS.

$a_0 = -2^s.1 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = +44^s.8$ for $19^h.8$

$$0 = \quad d\Delta T \quad da \quad dc$$
$$0 = \quad d\Delta T \quad da \quad dc$$
$$0 = \quad d\Delta T \quad da \quad dc$$

$d\Delta T = -0^s.021$	$\Delta T = +44^s.779$	(wt. = 7.99)
$da = -0.081$	$a = -2.181$	(wt. = 5.71)
$dc = +0.020$	$c = +0.220$	(wt. = 17.54)

Fresno, Cal., October 8, 1878; after signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	s.
δ Cephei	E.	22 23 55.13	0.06	+ 1.38	+ 0.61	22 23 57.12	22 24 42.04	+ 44.92
η Aquarii	E.	22 28 25.49		− 1.25	+ 0.32	22 28 24.56	22 29 09.32	44.76
ζ Pegasi	E.	22 34 42.62		− 0.93	+ 0.33	22 34 42.02	22 35 26.64	44.62
ι Cephei	E.	22 44 36.26		+ 2.39	+ 0.78	22 44 39.43	22 45 24.17	44.74
α Piscis Austr	E.	22 50 16.52		− 2.19	+ 0.38	22 50 14.71	22 50 59.18	44.47
Brad. 3077	W.	23 06 43.98		+ 1.26	− 0.59	23 06 44.65	23 07 29.02	44.37
α Cephei	W.	23 12 55.08		+ 2.73	− 0.84	23 12 56.97	23 13 41.56	44.59
ν Pegasi	W.	23 18 37.58		− 0.54	− 0.35	23 18 36.69	23 19 21.54	44.85
θ Piscium	W.	23 21 07.60		− 1.06	− 0.33	23 21 06.21	23 21 50.96	44.75
72 Pegasi	W.	23 27 13.93		− 0.25	− 0.38	23 27 13.30	23 27 58.24	44.94
ι Piscium	W.	23 33 01.33		− 1.08	− 0.33	23 32 59.92	23 33 44.78	+ 44.86

NORMAL EQUATIONS.

$a_0 = -2^s.1 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = +44^s.7$ for $23^h.0$

$$\begin{aligned} 0 &= -0^s.156 + 8.80\,d\Delta T + 1.49\,da - 0.80\,dc \\ 0 &= -0.344 + 1.49\,d\Delta T + 4.19\,da + 0.87\,dc \\ 0 &= -2.191 - 0.80\,d\Delta T + 0.87\,da + 17.46\,dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= +0^s.021 & \Delta T &= +44^s.721 & (\text{wt.} &= 8.20) \\ da &= +0.049 & a &= -2.051 & (\text{wt.} &= 3.89) \\ dc &= +0.124 & c &= +0.324 & (\text{wt.} &= 17.13) \end{aligned}$$

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Double wave time.	Means.
		h. m. s.	m. s.	h. m. s.	m. s.	s.	m. s.
October 5, 1878:							
Ogden	Ogden	22 12 35.00	− 2 18.386	22 10 16.614			
	Fresno	21 38 24.50	+ 0 42.535	21 39 07.035	31 09.579		
Fresno	Ogden	22 17 07.93	− 2 18.380	22 14 49.550			
	Fresno	21 42 57.30	+ 0 42.537	21 43 39.837	31 09.713	+ 0.134	31 09.646
October 6, 1878:							
Ogden	Ogden	22 06 30.00	− 2 16.697	22 04 13.303			
	Fresno	21 32 20.33	+ 0 43.435	21 33 03.765	31 09.538		
Fresno	Ogden	22 11 00.97	− 2 16.691	22 08 44.279			
	Fresno	21 36 51.10	+ 0 43.435	21 37 34.535	31 09.744	+ 0.206	31 09.641
October 7, 1878:							
Ogden	Ogden	22 16 30.00	− 2 15.246	22 14 14.754			
	Fresno	21 42 21.08	+ 0 44.144	21 43 05.224	31 09.530		
Fresno	Ogden	22 20 12.71	− 2 15.242	22 17 57.468			
	Fresno	21 46 03.60	+ 0 44.144	21 46 47.744	31 09.724	+ 0.194	31 09.627
October 8, 1878:							
Ogden	Ogden	22 35 00.00	− 2 13.726	22 32 46.274			
	Fresno	22 00 51.98	+ 0 44.744	22 01 36.724	31 09.550		
Fresno	Ogden	22 28 32.26	− 2 13.733	22 26 18.527			
	Fresno	21 54 23.90	+ 0 44.745	21 55 08.645	31 09.882	+ 0.332	31 09.716
Mean (4)							31 09.657

Final difference of longitude:

	°	′	″		h.	m.	s.
Fresno, Cal., west of Ogden, Utah	7	47	24.86	=	0	31	09.657
Ogden, Utah (transit pier), west of Greenwich	111	59	54.64	=	7	27	59.643
Fresno, west of Greenwich	119	47	19.50	=	7	59	09.300
Washington, D. C., west of Greenwich	77	03	01.80	=	5	08	12.120
Fresno, west of Washington, D. C	42	44	17.70	=	2	50	57.180

Tabulation of stars used for determination of time at Ogden, Utah, and Walla Walla, Wash.

Name of star.	Ogden. Aug. 12.	Ogden. Aug. 19.	Ogden. Aug. 21.	Walla Walla. Aug. 12.	Walla Walla. Aug. 19.	Walla Walla. Aug. 21.
ε Herculis						
ε Ursæ Minoris	1	1				
c Herculis	1	1				
ζ Draconis						
α Herculis	1	1			1	
δ Herculis	1	1				
e Herculis						
74 Herculis					1	
χ Herculis					1	
β Draconis					1	1
α Ophiuchi	1	1				
70 Herculis		1				
f Draconis						
ι Herculis	1	1				
β Ophinchi					1	1
μ Herculis					1	1
166 Heis Herculis	1	1				
f Herculis	1	1				
ξ Herculis	1	1	1			
γ Draconis					1	1
35 Draconis						
95 Herculis	1	1	1			
o Herculis			1			
22 H. Cameleopard sp					1	1
A Herculis			1			
δ Ursæ Minoris	1	1	1			
24 Ursæ Minoris						
η Serpentis					1	1
109 Herculis					1	1
8 Heis Lyræ			1			
χ Draconis						1
B.A.C. 6300			1			
3 H. Scuti					1	1
9 Heis Lyræ			1	1		
α Lyræ						1
11 Heis Lyræ			1			
110 Herculis						
51 H. Cephei sp	1		1			
β Lyræ				1		
o Draconis			1			
50 Draconis	1					
γ Lyræ	1					
16 Lyræ			1			
ζ Aquilæ	1			1		
ι Lyræ	1		1			
19 Lyræ	1		1			
δ Draconis				1	1	
τ Draconis	1					
δ Aquilæ				1	1	1
4 Cygni	1					
β Cygni	1					1
9 Cygni	1					
ν Aquilæ						
θ Cygni			1			
28 Heis Cygni			1			
γ Aquilæ					1	1
δ Sagittæ			1			
α Aquilæ					1	1
12 Vulpeculæ			1			
ε Draconis	1		1	1		1
β Aquilæ					1	
γ Sagittæ						
τ Aquilæ					1	1
η Sagittæ			1			
θ Sagittæ			1			
θ Aquilæ					1	1
o Cygni			1			
α^2 Capricornis					1	
κ Cephei			1	1		1
γ Cygni			1			
ε Delphini						
73 Draconis		1				
α Cygni		1				
ε Cygni		1				
Piazzi xx, 358		1				
μ Aquarii						

Tabulation of stars used for determination of time, &c.—Continued.

Name of star.	Ogden.			Walla Walla.		
	Aug. 12.	Aug. 19.	Aug. 21.	Aug. 12.	Aug. 19.	Aug. 21.
32 Vulpeculæ	......	1	......	......	......	......
ν Cygni	......	......	......	......	......	......
Br. 2749	......	1	......	......	......	......
60 Cygni	......	......	......	......	......	......
o^3 Ursæ Majoris, sp	......	......	......	......	......	......
61 Cygni pr	......	......	......	......	......	......
Piazzi xxi, 1	......	1	......	......	......	......
ζ Cygni	......	......	......	......	......	......
77 Draconis	......	1	......	......	......	......
ν Cygni	......	1	......	......	......	......
α Cephei	......	......	......	......	......	......
1 Pegasi	......	1	......	......	......	......
Piazzi xxi, 120	......	......	......	......	......	......
β Aquarii	......	......	......	......	......	......

Ogden, Utah, August 12, 1878; before signals.

Name of star.	Clamp.	T.			*b* B.	*a* A.	*c* C.	T′.			Æ.			Δ T.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
ε Ursæ Min	W.	16	59	42.28	+ 1.06	+ 5.16	− 1.12	16	59	47.38	16	58	31.19	− 1	16.19
ε Herculis	W.	17	05	01.00	+ 0.25	− 0.12	− 0.19	17	05	00.94	17	3	45.31	1	15.63
δ Herculis	W.	17	11	20.16	+ 0.22	− 0.33	− 0.17	17	11	19.88	17	10	04.16	1	15.72
[illegible] Herculis	W.	17	14	46.20	+ 0.28	0.09	0.19	17	14	46.20	17	13	30.58	1	15.62
α Ophiuchi	W.	17	30	35.76	+ 0.17	0.62	− 0.15	17	30	35.26	17	29	19.50	1	15.76
ι Herculis	E.	17	37	19.11	+ 0.24	+ 0.13	+ 0.22	17	37	19.70	17	36	03.90	1	15.80
166 Heis Herc	E.	17	46	57.77	+ 0.19	− 0.25	+ 0.17	17	46	57.88	17	45	42.11	1	15.77
f Herculis	E.	17	50	38.99	+ 0.23	− 0.03	+ 0.20	17	50	39.41	17	49	22.56	1	15.85
ξ Herculis	E.	17	54	20.04	+ 0.21	− 0.25	+ 0.17	17	54	20.17	17	53	04.40	1	15.77
95 Herculis	E.	17	57	38.60	+ 0.20	− 0.38	+ 0.16	17	57	38.58	17	56	22.79	1	15.79
δ Ursæ Min	E.	18	02	35.69	2.85	+ 12.77	+ 2.55	18	02	53.88	18	11	39.03	− 1	14.85

NORMAL EQUATIONS.

$a_0 = -1^s.04 \quad c_0 = +0^s.16 \quad \Delta T_0 = -75^s.75$ for $17^h.5$

$$
\begin{aligned}
0 &= +0.004 + 8.202\, d\Delta T + 1.122\, da + 0.880\, dc \\
0 &= -0.085 + 1.122\, d\Delta T + 4.518\, da - 0.633\, dc \\
0 &= -0.166 + 0.880\, d\Delta T - 0.633\, da + 20.022\, dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T &= +0^s.004 & \Delta T &= -1^m\ 15^s.746 & (\text{wt.} &= 7.96) \\
da &= -0.021 & a &= -1.061 & (\text{wt.} &= 4.34) \\
dc &= -0.009 & c &= +0.151 & (\text{wt.} &= 19.80)
\end{aligned}
$$

Ogden, Utah, August 12, 1878; after signals.

Name of star.	Clamp.	T.			b B.	a A.	c C.	T′.			Æ.			Δ T.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
51 Cephei H. sp	E.	18	44	32.36	4.63	14.87	3.04	18	44	09.82	6	42	53.27	− 1	16.55
50 Draconis	E.	18	51	32.54	1.24	+ 2.02	+ 0.58	18	51	36.88	18	50	20.27	1	16.11
γ Lyræ	E.	18	55	41.44	+ 0.47	0.16	+ 0.17	18	55	41.92	18	54	26.03	1	15.89
ζ Aquilæ	E.	19	01	07.46	+ 0.39	0.44	+ 0.15	19	01	07.56	18	59	51.71	1	15.85
ι Lyræ	E.	19	04	15.28	+ 0.54	− 0.10	+ 0.18	19	04	15.90	19	03	00.07	1	15.83
19 Lyræ	E.	19	08	23.81	+ 0.53	− 0.19	+ 0.17	19	08	24.32	19	07	08.41	1	15.91
z Draconis	W.	19	19	09.56	+ 0.97	+ 1.67	− 0.51	19	19	11.67	19	17	55.77	1	15.94
ι Cygni	W.	19	23	04.44	+ 0.37	− 0.10	− 0.18	19	23	04.53	19	21	48.69	1	15.84
β Cygni	W.	19	27	07.32	+ 0.42	− 0.24	− 0.17	19	27	07.31	19	25	51.47	1	15.84
θ Cygni	W.	19	31	19.26	+ 0.38	− 0.22	− 0.17	19	31	19.25	19	30	03.34	1	15.91
ε Draconis	W.	19	49	51.93	+ 0.59	+ 1.29	0.43	19	49	53.38	19	48	37.51	− 1	15.87

NORMAL EQUATIONS.

$a_0 = -0^s.93 \quad c_0 = +0^s.16 \quad \Delta T_0 = -75^s.87$ for $19^h.10^m$

$$0 = +0^s.139 + 7.372\,d\Delta T + 0.117\,da - 0.388\,dc$$
$$0 = -0.093 + 0.117\,d\Delta T + 5.853\,da - 1.689\,dc$$
$$0 = +0.303 - 0.388\,d\Delta T - 1.689\,da + 23.101\,dc$$

$d\Delta T = -0^s.020 \quad \Delta T = -75^s.890 \quad$ (wt. = 7.36)
$da = \pm 0.012 \quad a = -0.918 \quad$ (wt. = 5.73)
$dc = \pm 0.013 \quad c = +0.147 \quad$ (wt. = 22.59)

Ogden, Utah, August 19, 1878; before signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	A̶R.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
ε Ursae Minoris	E.	17 0 07.18	-0.21	+4.99	+0.51	17 0 12.47	16 58 29.99	−1 42.48
c Herculis	E.	17 5 28.03	−0.05	−0.11	+0.09	17 5 27.96	17 03 45.17	1 42.79
δ Herculis	E.	17 11 47.08	−0.04	−0.32	+0.08	17 11 46.80	17 10 04.05	1 42.75
e Herculis	E.	17 15 13.17	−0.05	−0.09	+0.09	17 15 13.12	17 13 30.44	1 42.68
α Ophiuchi	E.	17 31 02.81	−0.03	−0.50	+0.07	17 31 02.35	17 29 19.42	1 42.93
79 Herculis	E.	17 34 15.70	−0.04	−0.33	+0.08	17 34 15.41	17 32 32.50	1 42.91
ι Herculis	E.	17 37 46.40	−0.05	+0.12	+0.10	17 37 46.57	17 36 03.74	1 42.83
166 Heis Herculis	W.	17 47 25.32	−0.27	−0.24	−0.08	17 47 24.73	17 45 41.99	1 42.74
f Herculis	W.	17 51 04.45	−0.32	−0.03	−0.09	17 51 04.01	17 49 22.42	1 42.59
ξ Herculis	W.	17 54 47.68	−0.27	−0.24	−0.08	17 54 47.09	17 53 04.30	1 42.79
95 Herculis	W.	17 58 06.19	−0.25	−0.37	−0.07	17 58 00.50	17 56 22.70	1 42.80
δ Ursae Minoris	W.	18 13 12.10	−2.87	+12.35	−1.17	18 13 20.41	18 11 36.56	1 43.85

NORMAL EQUATIONS.

$a_0 = -1^s.01$ $c_0 = +0^s.13$ $\Delta T_0 = -102^s.77$ for $17^h\ 30^m$

$$
\begin{aligned}
&\ \ s.\\
0 &= +0.260 + 9.25\, d\Delta T + 1.42\, da + 2.48\, dc\\
0 &= +0.128 + 1.42\, d\Delta T + 4.61\, da + 0.69\, dc\\
0 &= +1.331 + 2.48\, d\Delta T + 0.69\, da + 21.17\, dc
\end{aligned}
$$

$$
\begin{array}{lll}
\quad s. & \quad m.\quad s. & \\
d\Delta T = -0.009 & \Delta T = -1\ 42.779 & (\text{wt.} = 8.56)\\
da = -0.016 & a = -1\ \ .026 & (\text{wt.} = 4.38)\\
dc = -0.061 & c = +\ \ 0.069 & (\text{wt.} = 20.49)
\end{array}
$$

Ogden, Utah, August 19, 1878; after signals.

Name of star.	Clamp.	T.	*b* B.	*a* A.	*c* C.	T′.	Æ.	Δ T.
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
73 Draconis	W.	20 34 51.56	−0.48	+1.74	−0.66	20 34 52.16	20 33 08.80	−1 43.56
α Cygni	W.	20 39 03.57	−0.21	+0.08	−0.25	20 39 03.19	20 37 19.69	1 43.50
ε Cygni	W.	20 43 03.87	−0.18	0.14	0.21	20 43 03.34	20 41 20.01	1 43.83
Pi. XX, 358	W.	20 48 5.23	−0.17	−0.22	−0.20	20 48 04.64	20 46 21.02	1 43.62
32 Vulpeculæ	W.	20 51 9.38	−0.17	0.22	−0.20	20 51 08.79	20 49 25.24	1 43.55
Bradl. 2749	W.	20 54 49.52	−0.69	+3.09	−1.02	20 54 50.90	20 53 07.43	1 43.47
Pi. XXI, 1	E.	21 05 15.55	−0.09	−0.19	+0.20	21 05 15.47	21 03 32.03	1 43.44
77 Draconis	E.	21 09 38.65	0.31	+2.35	+0.82	21 09 41.51	21 07 57.89	1 43.62
ν Cygni	E.	21 14 41.12	−0.10	−0.12	+0.21	21 14 41.11	21 12 57.69	1 43.44
1 Pegasi	E.	21 18 14.05	−0.08	0.33	+0.19	21 18 13.83	21 16 30.37	−1 43.46

NORMAL EQUATIONS.

$a_0 = -0^s.86 \qquad c_0 = +0^s.13 \qquad \Delta T_0 = -103^s.44$ for $21^h.0^m$

$$\begin{aligned} 0 &= +0^s.311 + 6.945\, d\Delta T - 0.117\, da - 1.974\, dc \\ 0 &= -0.170 - 0.117\, d\Delta T + 4.321\, da + 2.349\, dc \\ 0 &= -1.002 - 1.974\, d\Delta T + 2.349\, da + 20.184\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= -0^s.032 & \Delta T &= -1^m\ 43^s.472 & (\text{wt.} &= 6.75) \\ da &= +0.014 & a &= -\ 0.846 & (\text{wt.} &= 4.05) \\ dc &= +0.045 & c &= +\ 0.175 & (\text{wt.} &= 18.38) \end{aligned}$$

Ogden, Utah, August 21, 1878; before signals.

Name of star.	Clamp.	T.	bB.	aA.	cC.	T′.	Æ.	ΔT.
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
ξ Herculis	E.	17 54 55.84	−0.22	− 0.37	+ 0.20	17 54 55.45	17 53 04.26	− 1 51.19
95 Herculis	E.	17 58 14.37	−0 20	− 0.56	+ 0.19	17 58 13.80	17 56 22.68	1 51.12
o Herculis	E.	18 04 41.28	0.22	− 0.39	+ 0.20	18 04 40.87	18 02 49.94	1 50.93
A Herculis	E.	18 09 13.03	−0.22	− 0.31	+ 0.21	18 09 12.71	18 07 21.67	1 51.04
δ Ursæ Min	E.	18 13 6.55	−2.30	+18.79	+ 8.01	18 13 26.05	18 11 35.83	1 50.22
8 Heis Lyræ	E.	18 23 10.73	0.22	− 0.36	+ 0.21	18 23 10.36	18 21 19.39	1 50.97
B. A. C. 6300	E.	18 26 27.01	−0.20	− 0.51	+ 0.20	18 26 26.50	18 24 35.37	1 51.13
9 Heis Lyræ	E.	18 30 4.49	−0.22	− 0.34	+ 0.21	18 30 04.14	18 28 13.04	1 51.10
11 Heis Lyræ	E.	18 34 3.09	0.23	− 0.26	+ 0.21	18 34 02.81	18 32 11.75	1 51.06
51 Cephei H. sp	W.	18 45 5.15	+4.00	−25.31	+ 3.68	18 44 47.52	06 42 56.99	1 50.53
o Draconis	W.	18 51 17.50	−0.58	+ 0.95	− 0.35	18 51 17.52	18 49 26.33	1 51.19
16 Lyræ	W.	18 59 53.62	−0.45	+ 0.22	− 0.26	18 59 53.13	18 58 02.00	1 51.13
ι Lyræ	W.	19 04 51.67	−0.38	− 0.18	+ 0.22	19 04 50.89	19 02 59.95	1 50.94
19 Lyræ	W.	19 09 0.13	−0.36	− 0.32	+ 0.21	19 08 59.24	19 07 08.42	−1 50.83

NORMAL EQUATIONS.

$a_0 = -1^s.50$ $c_0 = -0^s.15$ $\Delta T_0 = 1^m\ 51^s.04$ for $18^h.5$

$$0 = +0^s.084 + 10.713\ d\Delta T + 1.664\ da + 4.475\ dc$$
$$0 = +0.273 + 1.664\ d\Delta T + 5.589\ da + 2.967\ dc$$
$$0 = +0.537 + 4.475\ d\Delta T + 2.967\ da + 24.964\ dc$$

$d\Delta T = -0^s.006$ $\Delta T = +1^m\ 51^s.084$ (wt. = 9.67)

$da = -0.065$ $a = -1.565$ (wt. = 5.11)

$dc = +0.030$ $c = +0.180$ (wt. = 24.98)

Ogden, Utah, August 21, 1878; after signals.

Name of star.	Clamp.	T.			b B.	a A.	c C.	T'.			Æ.			Δ T.	
		h.	m.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	m.	s.
θ Cygni	W.	19	35	4.62	− 0.53	+ 0.35	− 0.23	19	35	04.21	19	33	13.07	− 1	51.14
28 Heis Cygni	W.	19	39	58.13	0.41	− 0.28	− 0.17	19	39	57.27	19	38	06.11	1	51.16
δ Sagittæ	W.	19	43	52.66	− 0.34	0.61	− 0.15	19	43	51.56	19	42	00.50	1	51.06
12 Vulpeculæ	W.	19	47	44.51	− 0.36	− 0.52	− 0.16	19	47	43.47	19	45	52.28	1	51.19
ε Draconis	W.	19	50	27.71	− 0.89	+ 2.08	− 0.42	19	50	28.48	19	48	37.22	1	51.26
η Sagittæ	E.	20	01	40.28	− 0.31	− 0.58	+ 0.15	20	01	39.54	19	59	48.38	1	51.16
θ Sagittæ	E.	20	06	29.22	0.32	− 0.56	+ 0.15	20	06	28.49	20	04	37.27	1	51.22
o Cygni	E.	20	11	41.79	− 0.46	+ 0.19	+ 0.21	20	11	41.73	20	09	50.54	1	51.19
κ Cephei	E.	20	14	48.12	− 1.18	+ 3.98	+ 0.66	20	14	51.58	20	13	00.53	1	51.05
γ Cygni	E.	20	19	45.71	− 0.42	− 0.05	+ 0.19	20	19	45.43	20	17	54.30	− 1	51.13

NORMAL EQUATIONS.

$a_0 = -1^s.50 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m\ 51^s.16 \qquad \text{for } 20^h.0^m$

$$\begin{aligned}
&\qquad s. \\
0 &= -\ 0.009 + 7.75\, d\Delta T + 0.40\, da - 0.23\, dc \\
0 &= -\ 0.060 + 0.40\, d\Delta T + 2.68\, da - 0.74\, dc \\
0 &= +\ 0.102 - 0.23\, d\Delta T - 0.74\, da + 17.50\, dc
\end{aligned}$$

$$\begin{aligned}
& & & \quad m.\quad s. & \\
d\Delta T &= \ 0.000 & \Delta T &= -1\ 51.160 & (\text{wt.} = 7.69) \\
da &= +\ 0.021 & a &= -\quad 1.479 & (\text{wt.} = 2.63) \\
dc &= -\ 0.005 & c &= +\quad 0.145 & (\text{wt.} = 17.20)
\end{aligned}$$

Walla Walla, Wash., August 12, 1878; after signals.

The observations at Walla Walla on August 12 were made with instrument out of the meridian. In their reduction I employed the method given in Chauvenet's Astronomy, vol. 2. See pages 227 and those following. The principal data are:

Clamp.	Star.	T.	Assumed θ.	Rate i, to 19h.		α	δ	b
		h. m. s.	s.	s.		h. m. s.	° ′ ″	s.
E.	α Lyræ	18 33 5.90	+ 56	— 0.01		18 32 51.49	38 40 24	+ 0.125
E.	β Lyræ	18 46 34.94		— 0.01		18 45 37.03	33 13 28	+ 0.125
E.	ζ Aquilæ	19 2 49.76		0.00		18 59 51.70	13 41 6	+ 0.08
E.	δ Draconis	19 6 50.80		0.00	— 654″.9	19 12 33.99	67 26 59	+ 0.06
E.	δ Aquilæ	19 23 19.46		+ 0.01		19 19 24.61	2 52 29	+ 0.03
W.	ε Draconis	19 40 54.50		+ 0.02	— 489″.15	19 48 37.52	69 57 36	— 0.28
W.	κ Cephei	19 55 17.76		+ 0.03		20 13 0.95	77 20 45	— 0.28

Assumed $a = -425^s.00$.

The resulting equations are—

$$\begin{aligned}
0 &= \overset{s.}{+0.39} + 0.78\, d\Delta T + 0.13\, da + c \\
0 &= +0.43 + 0.84\, d\Delta T + 0.22\, da + c \\
0 &= -0.16 + 0.97\, d\Delta T + 0.54\, da + c \\
0 &= +1.27 + 0.38\, d\Delta T - 0.36\, da + c \\
0 &= -0.42 + 1.00\, \delta\Delta T + 0.68\, da + c \\
0 &= -0.11 + 0.34\, \delta\Delta T - 0.40\, da - c \\
0 &= +0.27 + 0.22\, \delta\Delta T - 0.52\, da - c
\end{aligned}$$

And their solution gives—

$$\begin{aligned}
d\Delta T &= \overset{s.}{+0.151} \text{ hence } \Delta T = +\overset{s.}{56.15} \text{ for } \overset{h.}{19.0} \\
da &= +1.655 \qquad a = -423.345 \\
c &= -0.772
\end{aligned}$$

Walla Walla, Wash., August 19, 1878; before signals.

Name of star.	Clamp.	T.			*b* B.	*a* A.	*c* C.	T'.			Æ.			ΔT.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
α Herculis	E.	17	08	12.08	0.22	4.22	0.29	17	08	7.35	17	09	08.10	+ 1	0.75
74 Herculis	E.	17	15	57.00	− 0.37	+ 0.06	− 0.41	17	15	56.28	17	16	56.78	1	0.50
χ Herculis	E.	17	22	32.67	− 0.38	+ 0.47	− 0.42	17	22	32.34	17	23	32.58	1	0.24
β Draconis	E.	17	26	41.71	− 0.42	+ 1.41	− 0.46	17	26	42.24	17	27	42.91	1	0.67
β Ophiuchi	E.	17	36	34.81	− 0.19	− 5.18	− 0.28	17	36	29.16	17	37	30.07	1	0.91
μ Herculis	E.	17	40	46.36	− 0.27	− 2.77	0.32	17	40	43.00	17	41	43.97	1	0.97
γ Draconis	W.	17	52	46.62	− 0.21	+ 1.19	+ 0.45	17	52	48.05	17	53	48.85	1	0.80
22 H. Camelopard	W.	18	04	47.87	+ 0.16	− 20.00	− 0.79	18	04	27.24	18	05	27.75	1	0.51
η Serpentis	W.	18	14	8.77	− 0.09	− 5.90	+ 0.28	18	14	3.06	18	15	03.46	1	0.40
109 Herculis	W.	18	17	35.81	− 0.13	3.46	+ 0.30	18	17	32.52	18	18	33.15	1	0.63
3 H. Scuti	W.	18	27	43.50	− 0.08	6.41	+ 0.28	18	27	37.29	18	28	37.94	+ 1	0.65

NORMAL EQUATIONS.

$a_0 = -7.^s6 \qquad c_0 = -0.^s3 \qquad \Delta T_0 = +1^m\ 0.^s55$

$$
\begin{aligned}
&\quad s.\\
0 &= -0.140 + 9.28\, d\Delta T + 4.20\, da + 3.43\, dc\\
0 &= +0.529 + 4.20\, d\Delta T + 4.82\, da + 2.22\, dc\\
0 &= -0.226 + 3.43\, d\Delta T + 2.22\, da + 16.69\, dc
\end{aligned}
$$

s.		*h.*	*m. s.*	
$d\Delta T = +0.101$	ΔT	(17.8)	$= +1\ 0.651$	(wt. = 5.48)
$da = -0.207$	a		$= -7.807$	(wt. = 2.90)
$dc = +0.020$	c		$= -0.280$	(wt. = 15.28)

Walla Walla, Wash., August 19, 1878; after signals.

Name of star.	Clamp.	T.			bB.	aA.	cC.	T′.			Æ.			ΔT.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
δ Draconis	W.	19	11	25.52	+ 0.17	+ 7.28	+ 0.66	19	11	33.63	19	12	33.77	+ 1	0.14
δ Aquilæ	W.	19	18	20.25	+ 0.05	− 5.25	+ 0.25	19	18	24.30	19	19	24.60	1	0.30
γ Aquilæ	W.	19	39	35.10	+ 0.06	− 4.55	+ 0.26	19	39	30.87	19	40	31.25	1	0.38
α Aquilæ	W.	19	43	57.62	+ 0.06	4.72	+ 0.25	19	43	53.21	19	44	53.60	1	0.39
β Aquilæ	W.	19	48	27.50	+ 0.05	4.95	+ 0.25	19	48	22.85	19	49	23.01	1	0.16
ε Aquilæ	E.	19	57	19.64	+ 0.04	4.87	− 0.25	19	57	14.56	19	58	14.63	1	0.07
θ Aquilæ	E.	20	4	10.15	+ 0.03	− 5.62	− 0.25	20	04	4.31	20	05	04.55	1	0.24
α Capricornis	E.	20	10	28.07	+ 0.03	− 6.73	− 0.26	20	10	21.11	20	11	21.38	1	0.27
γ Cygni	E.	20	16	55.23	+ 0.06	− 1.08	− 0.33	20	16	53.88	20	17	54.35	+ 1	0.47

NORMAL EQUATIONS.

$a_0 = -7^s.6 \qquad c_0 = -0^s.3 \qquad \Delta T_0 = +1^m\,0^s.30$

$$\begin{aligned} 0 &= +0^s.530 + 8.26\, d\Delta T + 4.47\, da - 1.01\, dc \\ 0 &= +0.290 + 4.47\, d\Delta T + 3.73\, da + 0.92\, dc \\ 0 &= -0.324 - 1.01\, d\Delta T + 0.92\, da + 11.48\, dc \end{aligned}$$

	s.		*m.* *s.*	*h.*	
$d\Delta T =$	0.029	$\Delta T =$	+ 1 0.271	(for 19.8)	(wt. = 2.51)
$da =$	0.056	a	− 7.656		(wt. = 1.12)
$dc =$	+ 0.048	c	0.252		(wt. = 9.71)

Walla Walla, Wash., August 21, 1878; before signals.

Name of star.	Clamp.	T.			*b* B.	*a* A.	*c* C.	T′.			Æ.			ΔT.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
β Draconis	W.	17	26	43.06	+ 0.41	− 2.60	+ 0.84	17	26	41.71	17	27	42.85	+ 1	1.14
β Ophiuchi	W.	17	36	18.33	+ 0.19	+ 9.56	+ 0.51	17	36	28.59	17	37	30.04	1	1.45
μ Herculis	W.	17	41	36.63	+ 0.27	+ 5.10	+ 0.58	17	41	42.58	17	41	43.94	1	1.36
γ Draconis	W.	17	52	48.48	+ 0.41	− 2.19	+ 0.82	17	52	47.52	17	53	48.79	1	1.27
22 H. Camelop. sp	W.	18	3	51.22	+ 0.31	+ 36.88	− 1.45	18	4	26.34	18	5	27.88	1	1.54
η Serpentis	E.	18	13	51.63	+ 0.10	+ 10.88	− 0.51	18	14	2.10	18	15	3.44	1	1.34
109 Herculis	E.	18	17	25.91	+ 0.15	+ 6.39	− 0.55	18	17	31.90	18	18	33.12	1	1.22
χ Draconis	E.	18	22	38.39	+ 0.46	− 21.67	− 1.72	18	22	15.46	18	23	16.87	1	1.41
3 H. Scuti	E.	18	27	25.22	+ 0.09	+ 11.83	− 0.52	18	27	36.62	18	28	37.92	1	1.30
α Lyræ	E.	18	31	48.12	+ 0.20	+ 2.37	− 0.66	18	31	50.03	18	32	51.36	+ 1	1.33

NORMAL EQUATIONS.

$a_0 = +14^s.0 \qquad c_0 = -0^s.3 \qquad \Delta T_0 = +1^m\,1^s.40$

$$\begin{aligned} &\quad\ \ s. \\ 0 &= -0.232 + 7.90\,d\Delta T + 3.42\,da + 1.83\,dc \\ 0 &= -1.144 + 3.42\,d\Delta T + 5.22\,da + 2.84\,dc \\ 0 &= +3.273 + 1.83\,d\Delta T + 2.84\,da + 17.00\,dc \end{aligned}$$

s.	*m.* *s.*	*h.*
$d\Delta T = -0.093$	$\Delta T = +1\ \ 1.307$ (for 18.0)	wt. = 5.66
$da = +0.395$	$a = +\ \ 14.395$	wt. = 3.49
$dc = -0.212$	$c = -\ \ 0.512$	wt. = 15.45

Walla Walla, Wash., August 21, 1878; after signals.

Name of star.	Clamp.	T.			bB.	aA.	cC.	T'.			Æ.			ΔT.	
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*m.*	*s.*
δ Aquilæ	E.	19	18	14.35	+ 0.13	+ 9.82	− 0.43	19	18	23.87	19	19	24.58	+ 1	0.71
β Cygni	E.	19	24	45.44	+ 0.19	+ 5.10	− 0.49	19	24	50.24	19	25	51.39	1	1.15
γ Aquilæ	E.	19	39	21.92	− 0.14	+ 8.51	− 0.43	19	39	30.14	19	40	31.24	1	1.10
α Aquilæ	E.	19	43	44.10	+ 0.14	+ 8.83	− 0.43	19	43	52.64	19	44	53.59	1	0.95
ε Draconis	W.	19	47	51.85	+ 0.46	− 16.94	+ 1.24	19	47	36.61	19	48	37.26	1	0.65
ζ Aquilæ	W.	19	57	4.06	+ 0.06	+ 9.11	+ 0.43	19	57	13.66	19	58	14.63	1	0.97
θ Aquilæ	W.	20	3	52.47	+ 0.05	+ 10.53	+ 0.43	20	4	3.58	20	5	4.54	1	1.06
κ Cephei	W.	20	12	31.03	+ 0.31	− 33.97	+ 1.94	20	11	59.31	20	13	0.53	+ 1	1.22

NORMAL EQUATIONS.

$\Delta T_0 = 1^m\ 0^s.90 \qquad a_0 = +\ 14^s.4 \qquad c_0 = -\ 0^s.5$

$$
\begin{aligned}
&\qquad\ \ s.\\
0 &= -\ 0.352 + 6.39\, d\Delta T + 2.80\, da + 0.41\, dc\\
0 &= -\ 0.260 + 2.80\, d\Delta T + 3.68\, da + 3.87\, dc\\
0 &= -\ 0.698 + 0.41\, d\Delta T + 3.87\, da + 12.49\, dc
\end{aligned}
$$

s.	*m.* *s.*	*h.*	
$d\Delta T = +\ 0.080$	$\Delta T = +\ 1\ \ 0.980$	(for 19.8)	wt. = 3.51
$da = -\ 0.070$	$a = +\ \ 14.330$		wt. = 1.36
$dc = +\ 0.075$	$c = -\ \ \ 0.425$		wt. = 6.90

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Double wave time.	Means.
		h. m. s.	m. s.	h. m. s.	m. s.	s.	m. s.
August 12, 1878:							
Ogden, Utah	Ogden	18 20 00.00	− 1 15.823	18 18 44.177			
	Walla Walla	17 52 24.72	+ 0 56.15	17 53 20.87	25 23.307		
Walla Walla	Ogden	18 24 58.92	− 1 15.836	18 23 43.084			
	Walla Walla	17 57 23.60	+ 0 56.15	17 58 19.75	25 23.334	+ 0.027	25 23.320
August 19, 1878:							
Ogden	Ogden	19 09 40.00	− 1 43.111	19 07 56.889			
	Walla Walla	18 41 32.66	+ 1 0.411	18 42 33.071	25 23.818		
Walla Walla	Ogden	19 13 51.08	− 1 43.123	19 12 07.957			
	Walla Walla	18 45 43.70	+ 1 0.411	18 46 44.111	25 23.846	+ 0.028	25 23.832
August 21, 1878:							
Ogden	Ogden	19 23 30.00	− 1 51.129	19 21 38.871			
	Walla Walla	18 55 13.86	+ 1 1.144	18 56 15.004	25 23.867		
Walla Walla	Ogden	19 17 53.28	− 1 51.114	19 16 02.166			
	Walla Walla	18 49 37.00	+ 1 1.144	18 50 38.144	25 24.022	+ 0.155	25 23.944
Mean (3)							25 23.700

Final difference of longitude:

	°	′	″		h	m.	s.
Walla Walla, Wash., west of Ogden, Utah	6	20	55.50	=	0	25	23.700
Ogden (transit pier), west of Greenwich	111	59	54.64	=	7	27	59.643
Walla Walla, west of Greenwich	118	20	50.14	=	7	53	23.343
Washington, D. C., west of Greenwich	77	3	1.80	=	5	08	12.12
Walla Walla, west of Washington, D. C	41	17	48.34	=	2	45	11.22

Geographical positions from sextant observations, variations of the needle, altitudes, &c.

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle, east.	Observer.	Computer.	Remarks.
					° ′ ″	*Feet.*	° ′			
1878..	Williamson's River	Oregon	29c	Polaris	42 44 45.2	4,387	18 35	Lieutenant Wheeler	Lieutenant Macomb	Camp 2.
1878..	Corral Springs	..do	28b	..do Sun	43 14 30.4	4,569		..do	..do	Camp 4.
1878..	Little Meadows, Deschutes River	..do	29a	Polaris Sun	43 27 43.6	4,258		Lieutenant Wheeler	Lt. Macomb & F. W. Floyd.	Camp 5.
1878..	Halfway Camp, Deschutes River	..do	29a	..do	43 41 00.1	4,081		..do	..do	Camp 6.
1878..	Big Meadows, Deschutes River	..do	29a	Polaris Altair Sun	43 52 02.2	4,124		..do	..do	Camp 8.
1878..	Farewell Bend, Deschutes River	..do	29a	Polaris Altair Sun	44 02 31.5	3,621		..do	..do	Camp 9.
1878..	Carmicals, Crooked River	..do	20c	..do	44 20 08.8	2,736		..do	..do	Camp 10.
1878..	Warm Spring Indian Agency	..do	20c	Polaris Altair	44 46 15.1	1,514		..do	Lieutenant Macomb	Camp 12.
1878..	Deadwood Peak	California	64b	Sun	37 18 36.3	4,451		Lieutenant Macomb	..do	

LIST OF SPECIMENS FORWARDED TO THE NATIONAL MUSEUM DURING THE FISCAL YEAR.

Zoological.

Birds:	
Species	289
Specimens	470
Reptiles:	
Lots	2
Specimens	12
Fishes:	
Lots	2
Specimens	15
Specimen	1
Mollusca:	
Lots	12
Specimens	30
Packages diatomaceous earth	11
Vertebrate fossils:	
Lots	8
Specimens	*500
Invertebrate fossils:	
Lots	9
Specimens	*1,072

Archæological.

6 steatite pots.
1 grinding stone.
1 sandstone mortar.
4 pestles.
2 baking stones.
4 stone pipes.
1 stone paint cup.
1 Abalone shell (paint cup).
1 lot native beads.
2 lumps native paint.
2 dishes, modern Pueblo pottery.
1 bowl, modern Pueblo pottery.

NOTE.—The collection of rocks, minerals, ores, &c., comprising over 4,000 specimens from various localities in the West, as mentioned in the summarized list in the Annual Report for 1879 as having been forwarded to the Smithsonian Institution, was, at the request of the officer in charge, donated to the museum at West Point, for use and exhibition there.

PUBLICATIONS.

Volume VII has appeared during the year; also extra copies of the Annual Report for 1879, being Appendix O O, Annual Report Chief of Engineers, accompanied by the following land-classification sheets, viz: 32*d*, 73*a*, 78*a*, 61*d*, 84*b*, and 47*b*+47*d*.

The following atlas sheets and maps remain unpublished:

* Approximate.

Topographical atlas-sheets (unpublished).

Atlas-sheet number.	Locality.	Scale.	Area.	Boundaries. Latitude north.	Boundaries. Longitude west from Greenwich.	Remarks.
			Sq. miles.	° ′	° ′ ″	
20 *a*, in part	Parts of Northern Oregon and Southern Washington	1 inch to 4 miles	3,859.85	44 50 45 40	120 37 30 122 00 00	More field-work required; land classification to be added.
20 *c*, in part	Part of Northern Oregon	...do	3,914.30	44 00 44 50	120 37 30 122 00 00	Do.
29 *a*, in part	Part of Central Oregon	...do	3,968.85	43 10 44 00	120 37 30 122 00 00	Do.
29 *c*, in part	Part of Southern Oregon	...do	4,022.58	42 20 43 10	120 37 00 122 00 00	Do.
32 *e*	Part of Southern Idaho	...do	4,022.58	42 20 43 10	112 22 30 113 45 00	Land classification to be added.
38 *b*, in part	Parts of Southern Oregon, Northwestern Nevada, and Northeastern California.	...do	4,075.29	41 30 42 20	119 15 00 120 37 30	Land classification to be added; more field-work required.
38 *d*	Parts of Northeastern California and Northwestern Nevada.	...do	4,127.18	40 40 41 30	119 15 00 120 37 30	Land classification to be added.
47 *a*	Part of Northern California	...do	4,178.42	39 50 40 40	120 37 30 122 00 00	Do.
48	Part of Central and Western Central Nevada	1 inch to 8 miles	16,313.96	39 00 40 40	116 30 00 119 15 00	In hachures only.
53 *d*, in part	Parts of Central Colorado	1 inch to 4 miles	4,228.56	39 00 39 50	105 30 00 106 52 30	Land and geological classification to be added; more field-work required.
56 *b*	Parts of Eastern California and Southwestern Nevada.	...do	4,278.00	38 10 39 00	119 15 00 120 37 30	Land classification to be added.
56 *d*, in part	Part of East Central California	...do	4,326.29	37 20 38 10	119 15 00 120 37 30	Land classification to be added; more field-work required.
68, in part	Parts of Northeastern Arizona and Northwestern New Mexico.	1 inch to 8 miles	17,587.88	35 40 37 40	108 15 00 111 00 00	More field-work required.
69, in part	Parts of Southern Colorado and Northwestern New Mexico.	...do	17,587.88	35 40 37 20	105 30 00 108 15 00	Land classification to be added; more field-work required.
73, in part	Part of Southern California	...do	17,952.24	34 00 35 40	116 30 00 119 15 00	More field-work required; land classification to be added.
73 *c*	...do	1 inch to 4 miles	4,510.27	34 00 34 50	117 52 30 119 15 00	Land classification to be added.

74, in part	Parts of Southeastern California and Western Arizona.	1 inch to 8 miles	17, 952. 24	34 00 35 40	113 45 00 116 30 00	More field-work required.
77, in part	Central New Mexico	do	17, 952. 24	34 00 35 40	105 30 00 108 15 00	More field-work required; land classification to be added.
80, in part	Part of Southern California	do	18, 301. 78	32 20 34 00	116 30 00 119 15 00	Do.
81, in part	Part of Southern California and Western Arizona	do	18, 301. 78	32 20 34 00	113 45 00 116 30 00	More field-work required.
84, in part	Part of South Central New Mexico	do	18, 301. 78	32 20 34 00	105 30 00 108 15 00	More field-work required; land classification to be added.
90 *a*, in part	Part of Southwestern New Mexico	1 inch to 4 miles	4, 638. 24	31 30 32 20	116 52 30 108 15 00	Do.
90 *b*, in part	Part of Southern New Mexico and Western Texas	do	4, 638. 24	31 30 32 20	105 30 00 106 52 30	Do.

NOTE.—Incidental to the survey of other atlas-sheets geographical material has been gathered in the following, viz: 11 C, 19 D, 20 B, 20 D, 28 B, 28 D, 29 B, 29 D, 31 D, 32 A, 32 B, 38 A, 38 C, 39 C, 39 D, 40 A, 40 B, 40 C, 46 B, 47 C, 51, 56 A, 56 C, 60 C, 60 D, 62 D, 64 B, 70 B, 70 D, 72 B, 72 D, 78 C, 82, 85 A, and 89.

GEOLOGICAL MAPS (UNPUBLISHED.)

Contour map of Ely mining district, Southern Nevada, 1 inch to 12 miles. Atlas sheets, 61*b*, 61*c*, 70*a*, 70*c*, and parts of 69*b*, 69*d*, 77*b*, and 78*a*, also 52*d*, in which more field-work is required.

LAND-CLASSIFICATION MAPS (UNPUBLISHED).

Atlas sheets, 32*c*, 38*d*, 47*a*, 52*d* (in part), 56*b*, 56*d* (in part), 69 (in part), 73*c*, 73, 77 (in part), 84 (in part).

SPECIAL MAPS (UNPUBLISHED).

1. Map of portions of Eastern California and Western Nevada, the Lake Tahoe region of the Sierra Nevada; area, 2,232 square miles; scale, 1 inch to 1 mile, or 1:63360.

2. Great Salt Lake and vicinity, area 5,719.8 square miles, plotted on a scale of 1 inch to two miles. (More field-work required.)

RECAPITULATION.

Topographical atlas sheets unpublished	23
Land-classification maps unpublished	11
Geological maps unpublished	7
Special maps unpublished	2
Total	43

TOPOGRAPHICAL MAPS AND PROGRESS SHEET.

Owing to large reductions in the office force it has only been possible to complete the following atlas sheet for publication, viz, 41*a*. The following sheets approach completion, viz: Lake Tahoe sheet, 32C, 38D, 52D, and 73C.

Work has progressed on the following other sheets: 32C, 47A, 56B, 56D, 61B (re-issue), 56D, 84, and 77.

There is, however, now at hand in this office material for the final publication (with land classification) of the atlas sheets numbered 32*c*, 38*d*, 41*a*, 47*a*, 56*b*, and 73*c*.

Atlas sheets 48, 52*d*, 73, 69, and 77 might also be published *entire* by some compilation from authoritative sources, although it would be more satisfactory if further and more complete data were gathered by parties of this survey.

Other atlas sheets, in which much field-work has been done, but which cannot be published entire without further field-work, are 20*a*, 20*c*, 29*a*, 29*c*, 38*b*, 56*d*, 68, 74, 80, 81, 84, 90*a*, and 90*b*.

Incidental to the survey of published and unpublished atlas sheets, geographical material has been gathered in a number of others already noted. This material is not sufficient in amount to warrant its publication in atlas-sheet form.

The progress map herewith submitted is intended to show graphically by the aid of colors the areas actually published, and those surveyed but not published, showing in the latter case the amounts meandered only and those both triangulated and meandered. In other respects this progress map does not differ from that of 1879 except in the addition of newly constructed railroads and changes in military posts.

The published and unpublished areas in square miles are approximately as follows, the unpublished being divided into four classes:

	Square miles.
Unpublished:	
1. Area of atlas sheets for which full material is gathered	18,626
2. Surveyed area in sheets requiring compilation from extraneous sources to publish entire	33,060
3. Area surveyed in atlas sheets which cannot be published entire without further field-work	52,299
4. Sum of small areas surveyed and lying in adjacent atlas sheets	6,300
Total surveyed and unpublished	110,285
Total surveyed and published	248,780
Total surveyed by United States geographical surveys west of the 100th meridian, from May 1, 1869, to June 30, 1879	359,065

ESTIMATES.

The sum of $30,000, estimated for the fiscal year 1880–'81, and appropriated by act approved June 16, 1880, will serve to reduce the greater share of the observations and print an edition of the more important maps.

It is estimated that for filling gaps in the triangulation and topographical work in the field, thereby admitting of the completion and publication of an additional number of atlas sheets, embracing an area of 52,299 square miles, the amount of $30,000 will be required for the fiscal year ending July 1, 1882.

FINANCIAL STATEMENT.

Amount expended from the appropriation for the fiscal year ending July 1, 1880	$19,543 57
Amount appropriated at the second session of the Forty-sixth Congress to complete the work of the geographical survey of the territory of the United States west of the 100th meridian	30,000 00

Respectfully submitted.

GEO. M. WHEELER,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, United States Army,
Washington, D. C.

APPENDIX Q Q.

EXPLORATIONS AND SURVEYS MILITARY DIVISION OF THE MISSOURI.

REPORT OF CAPTAIN JAMES F. GREGORY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

HEADQUARTERS MILITARY DIVISION OF THE MISSOURI,
OFFICE CHIEF ENGINEER,
Chicago, Ill., July 2, 1880.

GENERAL: I have the honor to submit the following report of operations for the fiscal year ending June 30, 1880:

There has been no field work in progress during the year. The office work has consisted in collecting, compiling, and plotting geographical information for the improvement of existing maps, in making reductions, enlargements, and fac-simile copies and tracings of maps of military reservations, scouts, reconnaissances, &c., for use at division headquarters, and for file and forwarding, and of battle maps for use of the Lieutenant-General and the Chickamauga board; in correcting, mounting, and issuing maps for use of officers on duty at these headquarters and elsewhere in the division.

Topographical Assistant George Henckel was discharged the service March 31, 1880, and Topographical Assistant Clarence E. Bagley was enlisted April 12, 1880. Topographical Assistant T. A. Petersen has rendered continuous service during the year.

Work on sheet No. 4, Western Territories, was suspended on the discharge of Assistant Henckel, and has not been resumed because the continuous labor of two assistants has been required to keep up with current work.

By the use of the potash, iron, and ammonia process of making photographic copies of tracings much time and labor has been saved in the duplication of maps of ephemeral value.

The chief engineers of the departments embraced in this division have, in accordance with instructions from the Lieutenant-General, forwarded to division headquarters copies of surveys, reconnaissances, &c., made under their direction, besides a monthly report of operations. Because of the total lack of funds for military surveys, very much was not to be expected; yet, as will be seen by reference to the appended list, a considerable amount of valuable information has been received.

Many reports of scouts, made by troops of the line in the various departments, have also been received. These are nearly always interesting, and give abundant evidence that the results expected from them were either accomplished or failed of attainment through no fault of the troops. The reports, however, even when accompanied by maps of route, contain little information that can be made available for purposes of map construction or correction.

I append a tabular statement showing the number of maps received, completed by hand, mounted and issued; also, list of maps and trac-

ings made; list of photographic copies of tracings made; list of work done for Quartermaster's Department; list of maps, tracings, &c., received from chief engineers of departments.

Very respectfully, your obedient servant,

JAMES F. GREGORY,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. Army.

TABULAR STATEMENT OF MAPS RECEIVED, COMPLETED BY HAND, MOUNTED, AND ISSUED.

Disposition.	Title of maps.														
	United States, showing military departments.	Yellowstone and Missouri rivers.	Western Territories.	Kansas, Texas, and Indian Territories.	New Mexico.	Indian Territory.	Colorado.	New Mexico and Arizona.	Territory of the United States west of the Mississippi River.	Dakota.	Montana.	Battle-field of Waynesborough.	Battle-field of Fisher's Hill and Cedar Creek.	Battle-field of Winchester.	Miscellaneous.
Received	......	......	......	......	......	......	25	31	7	3	3	307	295	271	[illegible]
Completed by hand	1	10	7	10	4	2	......	......	2	......	......	......	......	......	[illegible]
Mounted	1	2	2	2	1	2	4	4	2	2	2	......	......	......	[illegible]
Issued	1	10	7	10	29	2	11	7	2	2	2	3	3	3	[illegible]

LIST OF MAPS AND TRACINGS MADE.

2 maps showing route traveled by Lieutenant-General Sheridan and party through Colorado and New Mexico, in May and June, 1879.
1 tracing of lands belonging to San Felipe Agricultural Manufacturing and Irrigation Company, Texas.
1 tracing of San Felipe military reservation, Texas.
1 tracing of plan of the fourth story of government custom-house in Chicago.
1 tracing of Fort Meade military reservation, Dakota.
1 tracing of post of Fort Hale, Dak.
1 tracing of post of Fort Bennett, Dak.
1 tracing of post of Fort Shaw, Mont.
2 tracings of wood and timber reservation for Forts Sanders and D. A. Russell and Cheyenne Depot, Wyo.
1 tracing of wood reservation for Fort Robinson, Nebr.
1 tracing of military reservation of Fort Robinson, Nebr.
1 tracing of wood and timber reservation of Fort Cameron, Utah.
2 tracings of military reservations of Fort Niobrara, Nebr.
1 copy of Confederate map of the battle of Chickamauga.
1 tracing of map of site of Fort Brown, Tex.
1 copy of War Department map of the battle-field of Chickamauga, enlarged to twice the scale for the Chickamauga board.

Marked wagon-road, &c., on 5 maps of "Western portion of Colorado," published by the Ute Commission, October, 1878.
1 copy of sketches accompanying Captain Metcalfe's report on wax-filled bullets and Dougall rifle.
1 tracing of military reservation of Camp Sheridan, Nebr., as enlarged for wood and timber.
1 tracing showing great Indian trail across Dolores Plateau in Southwestern Colorado.
1 tracing of proposed wood and timber reservation of Fort Hall, Idaho.
1 tracing of proposed wood and timber reservation of Fort McKinney, Wyo.
1 tracing of the Cheyenne River, Dakota.
1 tracing of the located line of the Denver and Rio Grande Railroad—San Juan extension.
1 tracing of military reservation of Fort Keogh, Mont.
1 tracing of Kinney County, Texas.
1 tracing of post of Fort Keogh, Mont.
1 tracing of military reservation of Fort Assanaboine, Mont.
1 tracing of military reservation of Fort Dodge, Kans.
1 copy of map showing extension of the Atchison, Topeka and Santa Fé Railroad, from Trinidad to Santa Fé and the Rio Grande in New Mexico.
1 copy of map of battle-field of "Five Forks."
1 tracing of map of battle-field of "Five Forks."
1 copy of map of battle-field of "Dinwiddie Court House."
1 tracing of the cantonment on the North Fork of the Canadian River, Indian Territory.
1 tracing of military reservation of Fort Sanders, Wyo.
1 tracing of wood and timber reservation of Fort Sidney, Nebr.
5 tracings of military reservation of Fort Snelling, Minn.
2 tracings of post of Fort Snelling, Minn.
1 tracing of map published by the Southwest Colonization Company, Indian Territory.
2 tracings of military reservation of Fort A. Lincoln, Dak.
1 tracing of post of Fort Ellis, Mont.
1 tracing of post of Fort Lewis, Colo.
1 tracing of post of Fort Randall, Dak.
1 tracing of military reservation of Fort Randall, Dak.
1 tracing of post of Fort Logan, Mont.
1 tracing of military reservation of Fort Logan, Mont.
1 tracing of post of Fort Buford, Dak.
1 tracing of proposed wagon-road from Fort Bridger to Uintah Agency, Utah.
1 tracing of proposed military reservation of Fort Custer, Mont.
1 tracing of proposed national cemetery of Custer's battle-field, Mont.
1 tracing of proposed limestone reservation near "Old Fort C. F. Smith," Mont.
1 tracing of Indian and military reservation of Fort Totten, Dak.
1 tracing of post of Fort Totten, Dak.
1 tracing showing shore line of Rio Grande in 1869 and 1877 at Brownsville and Fort Brown, Tex.
1 tracing of proposed wood and timber reservation of Fort Niobrara, Nebr.

LIST OF PHOTOGRAPHIC COPIES OF TRACINGS MADE.

1 copy of military reservation of Fort Snelling, Minn.
1 copy of automatic gate and fence for military reservation of Fort Snelling, Minn.
2 copies of "map to accompany Col. Geo. P. Buell's report" on the proposed new military post west of Fort Lewis, Colo.
2 copies of military reservation of Fort Ridgely, Minn.
1 copy of proposed wood and timber reservation for Fort Meade, Dak.

WORK DONE FOR THE QUARTERMASTER'S DEPARTMENT.

1 tracing of map of plan of Fort Mc Kinney, Wyo.
1 tracing of map of part of Arizona District.
Compiled one map of the Military Division of the Missouri, showing all military posts and agencies and the various transportation routes.

LIST OF MAPS, TRACINGS, &C., RECEIVED FROM CHIEF ENGINEERS OF DEPARTMENTS.

Department of the Missouri.

Date.	Nature.	Description.	By whom made.
1879.			
July 1	2 maps	District of New Mexico, with the various routes marked thereon.	Lieut. C. A. Steadman.
Oct. 20	1 map	Showing military roads leading to Fort Lewis, Colo.	Captain Ruffner.
Dec. 8	7 tracings	Of reductions of the surveys of the Denver and Rio Grande Railroad Company.	Do.

Department of Dakota.

1879.			
Oct. 27	1 tracing	Route traveled by Third Battalion, Second Cavalry, in vicinity of Fort Custer during August, 1879.	Major Gordon.
Nov. 4	...do	Maps of military reservation of Fort Missoula and of post of Fort Missoula.	Lieut. Col. George Gibson.
1880.			
Jan'y 14	3 maps	Dakota Territory, edition 1878	Lieutenant Maguire.
Jan'y 14	...do	Montana Territory, edition 1878	Do.
March 8	1 tracing	Plat of military reservation of Fort Missoula, Mont.	Lieutenant Williams.
March 8	...do	Plat of post of Fort Missoula, Mont	Do.
March 8	...do	Plat of post of Fort Sully, Dak	Lieutenant Pettit.
March 8	...do	Plat of post of Fort Pembina, Dak	Lieutenant Hock.
March 8	...do	Plat of post of Fort Benton, Mont	Lieutenant Maguire.
March 8	...do	Plat of post of Fort A. Lincoln, Dak	Do.
March 8	...do	Plat of post of Fort Sisseton, Dak	Do.
March 8	...do	Plat of post of Fort Yates, Dak	Do.
March 8	...do	Plat of post of Fort Stevenson, Dak	Do.

Department of Texas.

1880.			
Feb'y 24	1 map	Route traveled between San Diego and Laredo, Tex., by a detachment of Eighth Cavalry in January, 1880.	Captain Kauffman.

APPENDIX R R.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE PLATTE.

REPORT OF CAPTAIN W. S. STANTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
ENGINEER OFFICE,
Fort Omaha, Nebr., July, 1880.

GENERAL: I have the honor to report, in compliance with General Orders No. 4, current series, headquarters Corps of Engineers, that my duties as engineer officer of this military department during the fiscal year which closed on the 30th ultimo, have been restricted to the ordinary routine of this office, for the want of any funds applicable to work, either in field or office, for the advancement of the map of the territory forming the department.

The collection from military posts and the surveyor-generals' offices of material necessary for the selection and location of fifteen military reservations, mostly for wood and timber, and its reduction to proper form for their declaration by the President, and, from the same sources, of the data necessary to prepare, for the War Department, correct plans of all the military posts, with maps of their reservations and inscriptions embodying all useful information attainable regarding them; the preparation of the plans in duplicate, mounting maps, and the survey of a pipe line, over 3 miles long, for supplying Fort Sanders with water, are the more noteworthy of the details with which, aided by the two topographical assistants, I have been occupied during the year.

The data from the surveyor-generals' offices, embracing the plots of 213 townships and a considerable mass of field notes, have been copied mostly by Corporal Ernst Wagner, Company B, Ninth Infantry, a sergeant of cavalry having also been detailed on this duty for two months.

For facilities given in securing these data my acknowledgements are due to Messrs. Geo. S. Smith and E. C. David, surveyors-general, respectively, of Nebraska and Wyoming.

Corporal Wagner is now at the office of the former, compiling a map of Nebraska projected on two sheets on a scale of 1 : 500,000.

A new post for three companies of cavalry and one of infantry is now building, of adobe and wood, on the right (south) bank of the Niobrara River opposite the mouth of Mini-Chaduza Creek, about seven miles within the northern boundary of this State.

The adopted line of communication with it is from Omaha by the Omaha division of the Saint Paul and Sioux City Railroad 163 miles to its present terminus at Oakdale; thence by the stage and mail route lying chiefly in the valleys of the Elkhorn and of the Niobrara, 165 miles to the post.

Another line is via the Union Pacific Railroad, 176 miles, to the terminus of one of its branches at Saint Paul, Nebr.; thence up the valley of the North Loup to Fort Hartsuff, up the Calamus to its source, and across

the divide to the post, 170 miles from the railroad at Saint Paul. While the wagon-route on the former line from Oakdale to the post is reported to be very favorable, that on the latter line from Fort Hartsuff to the post I found unfavorable when accompanying the department commander in his selection of the site for the post in July last.

From Saint Paul to Fort Hartsuff the route is good, and thence to the source of the Calamus fair, and the Niobrara lies for 33 miles in a region covered with low ranges of sand hills interlacing among broad, shallow, marshy basins covered with a vigorous growth of coarse grass.

In July we traversed, alternating with the sand hills, several miles of these basins through water standing several inches deep in the thick grass, while aquatic plants bordering the areas of greatest depression indicated seldom orn ever failing pools, which in some of the basins expand to the proportions of small lakes.

While this region of ponds and marshes between the sources of the Loups on the south, and of the short southern tributaries to the Niobrara on the north, is apparently without lines of drainage leading from it, the absorption of its rainfall seems to be prevented by an impervious stratum very near the surface. Evaporation from the broad surface of water thus retained in these ponds and marshes being greatly promoted by the heat imparted to the air by the action of the sun's rays on the extension surface of the intervening sand-hills, and saturation ensuing with a reduction of temperature, the water returns to the surface in copious rains giving to this region a humid character and green verdure which strikingly distinguish it from the more arid country surrounding it.

We saw this action very vividly when, at the close of a clear day of intense heat, dense clouds formed over the region and poured torrents of rain upon it, while hardly a drop fell at our camp near the Niobrara a few miles beyond its northern border. From meager, but the best, information attainable on the subject, this country of sand-hills, ponds and marshes seems to extend from a line somewhere between the sources of the Calamus and Elkhorn westward, perhaps, about 170 miles to the neighborhood of the 103d meridian, between the northern and southern limits before given.

A reconnaisance to determine its boundaries and run one or two profiles across it from the basin of the Loups to that of the Niobrara would be interesting in its results.

The route across it on the line from Fort Hartsuff to Fort Niobrara would be extremely difficult or impracticable during the summer months of greatest rainfall.

Fort Niobrara is 118 miles from Fort Hartsuff by this route and 141 miles from Camp Sheridan by a route ascending the valley of the river to the mouth of Antelope Creek, whence its course is quite circuitous.

Its construction is understood to be in furtherance of a desire of the owners of cattle herds for the protection of their herds and ranches in the valley of Niobrara against the Sioux. From the post the southern boundary of the Indian reservation is seven miles north, the Spotted Tail agency about 46 miles a little west of north, and Red Cloud agency about 104 miles a little north of west.

The topography, characteristics, formation, and resources in stone, timber, grass, and water of the valley of the Niobrara are so accurately and fully given in the printed report of Lieut. (now Lieut. Col. and Bvt. Maj. Gen.) G. K. Warren's Explorations in 1855, '56, '57, it would be superfluous to attempt to describe them here.

The burr oak (*Quercus macrocarpa*), also called over-cup white oak.

growing in beautiful groves in the vicinity of the post, is reported by the post commander, Major Upham, Fifth Cavalry, to warp excessively and to be of little value for building. The pine growing on the slopes of the bluffs along the river is dwarfed, small in diameter, and inferior for lumber, while the better quality growing in the deep cañons of the tributaries is almost inaccessible. It has therefore been found necessary to build the post quite largely of adobe.

During the year a small observatory for this office has been built at this post by the Quartermaster's Department with a special allotment of $300 authorized by the Secretary of War. It is a simple frame building, in the clear 14 by 10 by 6.5 feet at the eaves. The roof divides at the ridge, and its halves, resting on rollers, are easily moved down, up, or retained at any line by counterpoising weights which may be readily increased or diminished for the purpose. It incloses two brick piers capped with stone 2 feet square and resting on a common brick foundation extending well below the action of frost. The piers and building are so arranged that a zenith telescope or transit may be used on each in either the meridian or prime vertical.

Like all other Indian outbreaks leading to operations by the troops of this department, that of the Utes last September evinced an embarrassing want of information regarding routes, trails, &c., of the greatest importance in a campaign.

Such information and good maps of the West are more useful and indispensable to that large portion of the Army maintained on almost constantly active service in the Western military departments than to any other branch of the government. Its use for such maps and information of the West is more constant, more widely spread in territory, and serves larger and more vital government interests than that of any other executive branch.

Engineer officers assigned to duty with the troops for the express purpose of preparing these maps and acquiring this information have for years past been unable to secure any provision for their work in the annual appropriations, while a great many thousands of dollars have been supplied for special surveys under other executive departments of little if any use in the operations of the government, and but remotely and vaguely promoting its interests.

Three thousand dollars will be required for this work in this military department for the fiscal year ending June 30, 1882.

The following is a statement of money disbursed on account of this office during the year, viz:

In the office of the Chief of Engineers:	
For drawing materials	$95 75
For repairs of instruments	137 75
For materials for mounting maps	41 56
For extra-duty pay of two non-commissioned officers in copying township plots	50 00
	325 06
By the disbursing clerk of the War Department:	
For extra-duty pay of two non-commissioned officers in copying township plots	67 25
Total	392 31

Very respectfully, your obedient servant,

W. S. STANTON,
Captain of Engineers,
Chief Engineer of Department.

The CHIEF OF ENGINEERS,
U. S. Army.

APPENDIX S S.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF DAKOTA.

REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

HEADQUARTERS DEPARTMENT OF DAKOTA,
Chief Engineer's Office, Saint Paul, Minn., July 1, 1881.

GENERAL: I have the honor to submit the following report upon explorations and surveys in the Department of Dakota for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

EDWARD MAGUIRE,
First Lieutenant, Corps of Engineers, U. S. A.,
Chief Engineer Department of Dakota.

The CHIEF OF ENGINEERS, U. S. A.,
Washington, D. C.

REPORT.

The engineer detail in this department at the close of the last fiscal year consisted of myself, as engineer officer, two topographical assistants, and two privates of the Battalion of Engineers.

Topographical Assistant J. J. Durage was discharged the service August 20, and appointed assistant engineer for the examination and survey of the Cheyenne River. He was re-enlisted as topographical assistant November 23, 1879.

Private Thomas Culligan, Company A, Battalion of Engineers, was discharged the service by reason of expiration of term of service, June 23, 1880.

Topographical Assistant Wilson, accompanied by one private of Engineers, left Saint Paul, June 2, 1879, for Fort Custer, Mont., to make a survey of the reservation of that post, of the proposed cemetery of Custer's battle-field, and of a limestone reservation at and near old Fort C. F. Smith, Mont. The work was more than satisfactorily done. The report of the topographical assistant is appended.

Tracings of the three maps showing the reservations, and of the plan of the post, were forwarded to the Chief of Engineers. The reservation as surveyed were Fort Custer, 400 square miles; Custer's battle-field, 18 square miles, and Limestone, 3.48 square miles. The boundary lines were all run with transit and chain, and the work checked every few miles by observations for azimuth.

The road from Fort Custer to Fort Keogh, was measured with odometers by the topographical assistant. He also run a series of lines with transit and level at Fort Keogh to furnish the necessary data to the commanding officer for a system of water supply. He returned to Saint Paul October 29, and left again June 16, 1880, *en route* to Fort Assinaboine, to make a survey of that reservation.

In sending a party to make a survey of the Cheyenne River under the provisions of the river and harbor act of March 3, 1879, I directed the assistant engineer to make a reconnaissance from Fort Meade, Dak., to the Forks of the Cheyenne. This was done during the latter part of August. He reports that accompanied by the escort, consisting of one company of the First Infantry, under command of Capt. Leslie Smith, the party left Fort Meade August 25. The only route by which to reach the forks, which was recommended to them as practicable, was by way of "Madden's Crossing" of the fourth ford of the Cheyenne. The assistant says, in effect:

From Fort Meade, situated on "Bear Butte Creek," our route ran in a southeasterly direction through rolling country. After crossing some dry creeks leading towards Bear Butte Creek, we crossed "Alkali Creek," and following our course for about two miles, we turned sharply north and encamped on said creek, near the hay camp. The water in Alkali Creek is mixed with vegetable matter, is inclined to be stagnant, and is found in water-holes. Distance traveled, 10.07 miles.

August 26.—Starting in a southerly direction, then southeast, we had to pass over the bad lands of Alkali Creek Valley, to the summit of the southern bluffs. The progress was slow and the ascent very steep, requiring good management. Having gained the summit of this ridge the progress was very easy. The trail follows the edge of the bluffs. This ridge runs nearly east and west, descending steeply towards Alkali Creek, but sloping gently in a southerly direction towards Elk Creek Valley. At 23.15 miles from last camp we crossed Elk Creek running east, and encamped near the crossing. This crossing is deep and miry, the water is good, running and forming large deep water-holes. The grass is good, and wood is abundant. About 1,200 feet east lies the Deadwood freight route.

August 27.—Following the creek the trail is very good and well traveled. The surrounding hills are low and slope gently towards the creek. To the northeast, a distance of about 40 miles, I could distinguish a peak which I afterwards found to be 6 miles south of the Forks and east of the stream. At a distance of 3.91 miles we passed a ranch, the occupants of which informed us that there is a trail leaving their ranch and leading to the Forks across the country lying north of Elk Creek, but the country is too rough for wagon travel. At 10.86 miles from last camp we crossed Deep Creek (dry) and turned southeast. Having crossed a dry creek with small alkaline water-holes, the route winds its way through a more elevated country. At 14.83 miles from last camp we reached Lone-tree and encamped. Lone-tree Creek or Soldiers'-holes contains water in deep holes and has an underground current. The water is good, but owing to the great travel of ox-trains over this route good grass is only to be found far off. Wood is very scarce.

August 28.—Ascending the hills on the right bank of Lone-tree Creek we arrived at a rolling plateau, crossed some shallow creeks with small water-holes, and at 3.53 miles from last camp passed a small pond with permanent water, called commonly "The Lake." No trees or brush in the vicinity. At 9 a. m. we reached the junction of the Rapid City and Deadwood routes. This route is called The Territorial Highway. After crossing another dry creek with some small water-holes we reached the Cheyenne River Heights, about 250 feet above the bottom, turned sharply north and descended through a ravine to the river bottom. The descent is very steep and dangerous. Reaching the river bottom we turned eastward, and a short ride brought us to the bank of the river. The river at this point is about 128 feet wide and at the deepest point

2 feet deep, and running very slowly. The bottom is sandy. The ford is easy. This crossing is known by the name of Madden's Crossing. The distance from last camp is 18.11 miles, and from Fort Meade 66.16 miles. The ascent of the high bluffs on the right bank is very steep but not dangerous. Reaching the summit we left the highway, and starting in a northerly direction we followed the edge of the bluffs. Turning slightly northeast we descended through ravines to the bottom of Bull Creek, and following its course we reached the Cheyenne River bottom and encamped.

Observations were taken on this point to ascertain the proper position of the crossing of the highway, and the results show that this crossing is situated north of the one marked down on the department map and described by the land office of Dakota Territory. Distance traveled 22.48 miles. Soundings taken at this point give the channel a depth of 2 feet and a breadth of 15 to 17 feet. The river is 92 feet wide. About 800 feet below camp bars cut up the river into several channels of a greatest depth of about 1 foot. River bottom is fine gravel and sand.

August 29.—Traveled down stream, following a dim travois trail; crossed and recrossed the river four times. At 3.81 miles we arrived opposite the mouth of Elk Creek, traced on the map as emptying into the Belle Fourche. The crossing of the river was tedious and consequently only 14.36 miles could be accomplished. About 2 miles to the east of camp stands the peak observed on the 27th.

August 30.—Having traveled a distance 5.95 miles we arrived at the forks of the river and encamped about one mile down stream. A tracing of this reconnaissance was forwarded to the Chief of Engineers.

I take pleasure in forwarding to the Chief of Engineers a very interesting botanical report by Assistant Surgeon V. Havard, U. S. A. It is an elaboration and extension of the botanical outlines by the same author, which was printed with my report for the year ending June 30, 1878.

On August 19 I left Saint Paul with one enlisted man of engineers *en route* to Fort Ellis, to take some astronomical observations. Owing to the very low stage of the Missouri and an accident to the boat on which I started I did not reach Benton until September 17.

On arriving at Helena I found that it would be necessary for me to make an examination of the Missouri River above the falls by descending it in a mackinac. This duty was performed and I arrived at Fort Ellis October 2. I remained at the post until October 13, but was unable to do any work on account of the bad weather. On the latter date I left on the stage for Fort Keogh. The stage route runs to Benson's Landing on the Yellowstone, thence on the north bank of that river to Huntley, where the river is crossed to go to Fort Custer. The weather was very bad, and the roads as well as the stage stock in a terrible condition. I reached Keogh at 11.45 p. m. October 17. While at Keogh I made an inspection of the work at Buffalo Rapids.

I left the fort October 25 to go to the end of the Northern Pacific Railroad track by ambulance. We passed over no new country and the trip was an uninteresting one. The weather was very severe. I arrived in Saint Paul November 4.

While at Fort Ellis I went to Bozeman, Mont., at the request of the board of school trustees, and inspected and reported to them upon the condition of the school-house.

The valleys of the Yellowstone and its tributaries appear to be rapidly filling up with settlers. Major McElrath, of the Interior Department, at

Miles City, furnishes me with the following information concerning the Yellowstone Valley:

Observations at Keogh, January 13, 1879, to April, 1880.

	Rainfall.	Temperature, highest.	Temperature, lowest
	Inches.	*Fahr.*	*Fahr*
January	0.26	36	[illegible]
February	0.69	52	−[illegible]
March	0.28	76	−[illegible]
April	2.20	76	[illegible]
May	2.75	85	[illegible]
June	5.23	94	4[illegible]
July	5.90	100	[illegible]
August	1.84	97	[illegible]
September	0.44	96	
October	2.47	90	[illegible]
November	0.11	64	−[illegible]
December	0.58	42	−[illegible]
January	0.32	50	−[illegible]
February	0.17	54	−[illegible]
March	0.51	72	−[illegible]

For the month of March, 1880, a comparatively accurate census gives the following summary above Keogh:

	Total number
Ranchmen	21[illegible]
Ranchwomen	[illegible]
Women	[illegible]
Children	14[illegible]
Laborers	15[illegible]
Buildings	[illegible]
Acres in claims	32.4[illegible]
Acres under cultivation	1.71[illegible]
Cattle	23.4[illegible]
Horses	64[illegible]
Ponies	1[illegible]
Mules	[illegible]
Sheep	[illegible]
Hides taken	10 [illegible]
Bushels of oats	22.2[illegible]
Bushels of potatoes	10.[illegible]
Entries of corn	[illegible]
Entries of wheat	[illegible]
Entries of vegetables	[illegible]
Gardens	6[illegible]

The permanent population of Miles City is 600, and there are 54 settlers between that city and Fort Buford.

Tongue River Valley is settled to within three miles of Tongue River Cañon, fully 150 miles from the mouth of the river. There are, in all, 7[illegible] ranches. The productions are varied, including grain, hay, stock, cattle, sheep, vegetables, and milk and butter.

At Fort Snelling several detailed surveys were made in connection with the establishment of department headquarters on that reservation. The office has been called upon for a great deal of work in the way of laying out the buildings and roads, estimating necessary cut and fill for the grounds, in making plans and estimates for a system of water-works, &c.

The office work consisted in computing and platting the field notes, revising and connecting the maps of Dakota and Montana, in making numerous tracings for forwarding and for file in this office, and in supplying such information and data as were called for by the department commander and other officers.

LIST OF PLANTS FOUND ON THE PLAINS OF WESTERN DAKOTA AND EASTERN MONTANA DURING THE SUMMER OF 1877 AND SPRING OF 1879, BY V. HAVARD, ASSISTANT SURGEON, U. S. A.

This list contains 375 species, 62 of which are woody, and 313 herbaceous.

The country which it covers and characterizes may be defined as the northwestern plains, including the northwestern quarter of Dakota and that portion of Montana lying east of the Rocky Mountains. The main streams watering it are the Upper Missouri, from Fort A. Lincoln to the Falls, the Yellowstone from its mouth to the Cañon, the Musselshell, and Milk River up to the boundary line.

The northwestern plains are mostly underlaid by cretaceous or lignite tertiary beds. They are generally rolling, often broken into buttes and bad lands, and as their name implies, without mountain ranges. Their soil is sandy alluvial, more or less alkali in bottoms and bad lands, and gravelly on table lands. In altitude they range from 1,640 feet at Bismarck to about 3,000 at Benton. Their great meteorological features are long and severe winter and smallness of rainfall.

This paper is complementary to the "Botanical Outlines," published in Appendix Q Q of the Report of the Chief of Engineers for 1878; it is a study of the same subject, but under quite different aspects. It contains the enumeration *in extenso* of all the plants seen in the region whose flora was merely sketched in the "Outlines." Some repetition was unavoidable; the trees and shrubs, specially described in the latter paper, necessarily reappear in this, but mostly shorn of all details already published.

The plants of this list were observed or collected during the summer of 1877, while serving with the Seventh United States Cavalry, and during the spring of 1879, while accompanying the Eighteenth United States Infantry to Fort Assinaboine, Mont. They are arranged by familes in the order of Gray's Manual. The state of the plant with regard to its flower or fruit is generally stated; if found in flower, the date of collection or period of blossming simply appears without remark.

To Mr. Sereno Watson, of Cambridge, for his assistance in determining many species, and other courtesies, I feel under great obligations.

With a view to exhibit clearly the range of woody, and that of a few attractive herbaceous species, I shall trace them along the Missouri and its principal tributaries, so as to present, as it were, the botanical physiognomy of these streams. This will also have the advantage to bring the subject within the easy understanding of those not specially interested in botany.

Missouri.

At Fort A. Lincoln, our starting point, the valley of the Missouri is wide and covered with forests of cottonwood; willow thickets line the shores. At intervals, on dry ground, are small groves of elm, box-elder, and ash. On higher grounds, along the bluffs, are a few oak. The bullberry, osier, dogwood, rosebush, and snowberry abound. The Missouri currant, prickly gooseberry, and choke-cherry are also common. The following vines are frequently seen: Virgin's bower, winter grape, and poison ivy; less common are the Virginian creeper and the hop, and rare is the climbing bittersweet. On the slopes and covering the top of the bluffs are seen brown and green patches of ground cedar. The red cedar begins to appear on the bluffs above the Little Missouri, and is common thence.

These general features are preserved until the mouth of the Yellowstone is passed; then the Missouri narrows perceptibly, and the large tracts of cottonwood become much reduced. The oak has disappeared, the elm grows scarce, and will also soon disappear. Ash, nowhere common, decreases above the Yellowstone; sparse groves, farther between, above Peck, are seen as far as Carroll. Box-elder is now more common, extending up ravines with clumps of ash.

Poplar Creek is well timbered with cottonwood, willow-leaved poplar, ash, and box-elder.

Above Wolf Creek is first noticed the characteristic sage brush of the Missouri and Yellowstone (*Artemesia cana*).

Above Peck the river grows still narrower and the bluffs bolder and more precipitous. On their distant summits are seen a few pines (*Pinus ponderosa*), which increase in number and size as we proceed farther up. First seen on the tops in the early morning from the steamboat deck, they gradually descend down the slope as we advance, and late in the evening have reached the river bank in the vicinity of Fort Hawley. The red cedar has now disappeared from the bluffs, and near the mouth of the Musselshell is seen on the shore in the strange company of cottonwood and willows; it becomes scant above Armell's Creek.

Above Carroll timber grows scarce in the contracted valley; long reaches of river without cottonwood are passed. Steamboats now take in pine and cedar for fuel. Above Cow Island the river runs between bare buttes worn into fantastic shapes. The scant fuel costs twice as much as below the Musselshell. Little clumps of cottonwood and willows appear here and there on the edge of the valley at the mouth of a

tributary, or again on an island. With those exceptions the Missouri is mostly destitute of arborescent vegetation, and remains so as far as the Falls and probably much beyond. Between the Coal Banks and Benton small groves of box-elder are seen scattered on the shores.

After passing the Marais River, first appear the two poplars, which, from their constant association, may be called companion poplars (balsam poplar and willow-leaved poplar), mixed with cottonwood. The latter grows scarce; only a few are seen above Benton, and at the Falls has completely disappeared, being superseded by the two former.

There is no timber at Benton, nothing but willow brush along the banks and a few half-grown cottonwood in the distance. The same destitution continues above Benton, where the banks soon narrow into a rocky cañon.

At the Falls I noticed several clumps of balsam and willow-leaved poplar, box-elder, red cedar; on the declivity of the banks, choke-cherry, prickly gooseberry, and rosebush. No pine was seen either on the banks or the grassy plains above.

Yellowstone.

The flora of the Lower Yellowstone does not materially differ from that of the Missouri. The valley rising sooner to a higher level, the soil being less alluvial and more gravelly, and the temperature distinctly higher, we find, in consequence, a greater variety of species.

The arborescent vegetation, however, remains about the same. The cottonwood and willows continue to be the prevalent timber. Elm, scant near the mouth, soon disappears. Sparse groves of ash are found above Tongue River.

Many showy flowers deck the valley and the slopes in the spring: *Leucocrinum Montanum*, *Penstemon acuminatum*, and *album*, *Gaura coccinea*, *Oxytropis*, *Lambertii* and *Campestris*, *Lupinus perrennis*, and various astragali, &c. Above Cedar Creek blossom early the two elegant species of *Fritillaria* (*atropurpurea* and *pudica*) two of *Zigadenus* (*Nuttallii* and *paniculatus*), and, somewhat later, the sega plant (*Colochortus Nuttallii*) and several species of Ænothera, principally the *pinnatifida* and *coespitosa*. All bottoms are covered with white sage-brush (*Artemesia cana*). On the bluffs is commonly seen the *Yucca Angustifolia*.

After reaching Custer Creek new shrubs attract attention: the western sage-bush (*Artemesia tridendata*, and occasionally the *trifida*), and the grease-bush (*Sarcobatus vermiculatus*) which flourishes on bad-lands. Now also abounds the notorious grass, porcupine or spear-grass (*Stipa comata*), whose barbed seeds in August adhere obstinately to man and horse alike. More noisome still is the ubiquitous Missouri cactus.

The ground cedar is common but the red cedar is rarely seen east of Tongue River; thence common. The choke-cherry, rosebush, bullberry, hop, and several gooseberries are found mostly everywhere. The bluff pine is first seen on the hills of Porcupine Creek; thence common. The cottonwood, above Clarke's Fork becomes mixed with the companion poplars; it is mostly replaced by the latter at the mouth of the Big Rosebud, and disappears a short distance further up. Above Clarke's Fork, box-elder is a common tree on the valley.

The Yellowstone is well timbered in its lower and upper portions, but the middle portion is occasionally bare. It is nowhere below the cañon contracted like the Upper Missouri, or, like it above Carroll, destitute for many miles of arborescent vegetation.

The Lower Yellowstone, from its mouth to Glendive Creek, and the Upper Yellowstone, from Tongue River upward, seem to possess great advantages as farming districts, having a good soil, temperate climate, and unbounded facilities for raising stock.

The tributaries of the Yellowstone east of the mountains are mostly timbered with cottonwood as far as Clarke's Fork; above that stream the companion poplars supersede it. Box-elder in small groves, aspen and western alder in thin clumps grow on Clarke's Fork a few miles above its mouth; on the Big Rosebud pine is added to these.

Musselshell.

On the Musselshell cottonwood is the prevalent tree; at the bend it becomes mixed with balsam and willow-leaved poplars and disappears a short distance above Colonel Stanley's crossing. Choke-cherry and Missouri currant are abundant.

Judith Basin.

In the Judith Basin the bluff-pine covers the hills. Aspen, the companion poplars, willows, and the western birch, grow on the banks of streams.

Milk River.

On Milk River the timber consists essentially of cottonwood and willows as far as the boundary line. Cottonwood extends likewise into its tributaries, but only for a

short distance, being soon replaced by the companion poplars. On many of these tributaries, north and south, box-elder is the prevalent tree, and has given its name to several of them.

On the Marais and Teton Rivers, both fairly timbered, the companion poplars preponderate and supply most of the lumber and fuel procurable at or above Benton.

TEMPERATURE AND RAINFALL.

With the hope to enable the reader to form a more intelligent conception of the agricultural capabilities of this region, I have, as far as imperfect statistics would allow me, computed its temperature and rainfall.

The results obtained, in their general bearing, are not new, and make no claim to originality; they confirm what is, I believe, already accepted principles in climatology, and illustrate these principles in their application to this limited zone. In a more particular way they permit me to point out several local influences and variations which may add to our knowledge of the meteorological peculiarities of the northern plains.

Temperature.

It is known that on the same parallel the mean annual temperature presents sensible variations which are, to a certain extent, independent of altitude or other local causes. The 47th degree of latitude, being that of the Northern Pacific Railroad, and nearly the central line of the Dakota plains, was the one selected for my inquiries. I found that on that parallel the lowest temperature is on or near the Mississippi Valley, and the highest on the Pacific coast; the extremes being 34°.5 on the meridian of Fort Ripley, Minn., and 52°.2 on that of Fort Lapwai, Idaho.

In the following figures, whenever any stated place is not on or near the 47th degree, an approximate correction is made for difference of latitude on the basis of 1°.5 Fahr. for each degree of latitude; in other words, unless otherwise stated, the temperature is for the meridian of that place where it crosses the 47th degree.

Starting from Chatham, N. B., with a mean of 39°, the temperature increases slightly as we remove from the coast, being 40°.6 at Quebec. It remains about the same across the lakes as far as Duluth, viz, Alpena, Mich., 40°; Fort Brady, Mich., 39°.7; Marquette, Mich., 42°; Duluth, Minn., 41°. These figures seem to denote a slight rise along the western half of Lake Superior. From Duluth the mean temperature falls rapidly, and reaches its minimum near the Mississippi Valley; thus the meridian of Fort Ripley, Minn., on the 47th degree (mean of three years) is only 34°.5. Farther south the minimum mean is thrown farther west, as seems to be shown by the corrected temperatures of Saint Paul (39°.9) and Fort Wadsworth, Dak. (36°.7); so that the minimum line may be drawn obliquely from Brainerd to the headwaters of the Minnesota River. From the minimum line westward a steady though irregular increase is noticed; this increase is 5°.1 from Ripley to Bismarck, and 6°.2 from Wadsworth to Fort Sully, Dak. The following table of mean temperatures, corrected for latitude, is introduced for reference. The places enumerated are arranged in the order of their longitude:

Fargo, Dak	37.2
Wadsworth, Dak	36.7
Jamestown, Dak	37.5
Bismarck, Dak	39.6
Fort Stevenson, Dak	39.2
Fort Buford, Dak	39.5
Fort Keogh, Mont	46.5
Fort Benton, Mont	45.4
Fort Shaw, Mont	45.5
Fort Baker, Mont	38.2
Fort Ellis, Mont	38.1
Fort Lapwai, Idaho	52.2
Fort Colville, Wash	48.4
Olympia, Wash	51.3
Cape Disappointment, Wash	50.0

The mean of Bismarck is slightly above that of the same parallel for a considerable distance west and east of it; on the Missouri it is only reached again above Fort Buford, but on the Yellowstone the temperature rises at a much more rapid rate, and is 47°.2 at the mouth of Tongue River (Fort Keogh), so that it is probable that the increase from Bismarck overland to Keogh is immediate and constant.

The difference between the temperature of the lakes and that of the Mississippi Valley is shown again by comparing the actual mean of Marquette and Duluth with that of Saint Paul; though the latter town is nearly 2° south of the former two, its mean (42°.9) is only 0°.1 higher than that of Marquette (42°.8) and 1°.5 higher than that of Duluth (41°.4), while in the latter case it should be at least 3°.

The general rise of the thermometer as we advance west of the Mississippi is also well established by comparing the actual means of Saint Paul (42°.9) and Fort Sully, Dak. (47°.), both places being very nearly on the same latitude.

From Buford the rise is rapid and striking to Benton and Fort Shaw. The fall noticed for Baker and Ellis is only apparent; these two posts being at an elevation of about 6,000 feet above sea level, a correction for altitude would raise their mean to at least that of Shaw, whose altitude is only 3,030 feet.

Beyond the mountains the mean is much higher, and reaches its maximum on the meridian of Fort Lapwai. Thence to the coast (mouth of the Columbia River) there seems to be a slight decline.

The mean of the forty-seventh parallel, at least east of the Rocky Mountains, is low, not from the moderate temperature of the summer, which is generally hot and dry, but from the excessive cold of the winter, which, from October to April, holds land and water fast in its icy bounds. The gradual rise noticed west of the minimum line, especially west of the Buford meridian, is due, not so much to any increase of summer heat, as to that of the winter, rendering the temperature, *pro tanto*, more equable, and, therefore, the climate more desirable. Thus the difference between the summer means of Rice and Benton (uncorrected for latitude) is only 0°.25 in favor of Benton, while the difference between the winter means of those two posts is 2°.5 likewise in favor of Benton. A correct way to express the relation of the winter temperature to that of the whole year would be to divide the annual by the winter mean; the higher the latter, of course the smaller the quotient; that is to say, the more even and temperate the climate. Thus, comparing Fort Snelling, Minn., with Fort Sully, Dak., two posts on the same latitude, we obtain 1°.97 for the former and 1°.74 for the latter, the actual difference between the winter means being 5°.

The results obtained for other posts (uncorrected for latitude) are as follows:

Fort Ripley	2.3
Fort Seward	2.2
Fort Lincoln	1.8
Fort Keogh	1.7
Fort Benton	1.6
Fort Shaw	1.5

They show clearly in what proportion the winter grows milder as we advance west; they also show that the winter of Keogh is much milder than that of corresponding points on the Missouri.

The foregoing statistics are confirmed by observing the different stages of the vegetation along the Missouri in various places at about the same time. The milder the winter, of course the earlier will appear the evidences of coming spring; in other words, the more advanced will be the vegetation; this is a country where the farmer must plant and reap early; to avoid the heat and drought of summer is an important point. The following notes, taken this spring, although very incomplete, bear out and illustrate meteorological observations. They tend to show, however, what I believe is true, that the vegetation at Buford is at least as forward as at Lincoln, and not behind it, as the difference between the winter means would lead us to expect.

April 16, Brainerd.—Ice on the ponds.

April 15, Morehead.—New grass hardly perceptible; one solitary plant in bloom—*Anemone patens.*

April 17, Bismarck.—White frost on the grass.

April 18, Missouri River.—Elm in blossom; not yet leafing.

April 20, above Berthold.—Two umbelliferæ opening their blossoms—*Peucedanum macrocarpum* and *Cymopterus glomeratus.*

April 24, above Buford.—Perceptible advance in vegetation over that of the previous few days; willow buds bursting and bullberry bushes turning yellow; banks now covered with green grass.

April 26, Wolf Creek.—Willow, bullberry, and prickly gooseberry in full bloom.

April 29, Peck.—Cottonwood leafing.

May 1, Carroll.—Strawberry in bloom; cottonwood with full-grown foliage.

May 2, above Cow Island.—Several flowers first seen on shore: *Fritilaria, Dodecatheon, Thermopsis, Viola,* &c.

May 4, Coal Banks.—Quite a number of new species in blossom: *Pentstemon, Astragalus, Phlox, Oxytropis, Comandra, Rumex, Allium,* &c.

May 20, Falls of the Missouri.—Vegetation distinctly more advanced than at Coal Banks and Fort Assinaboine, left on previous day. Rosebush first seen in blossom; (*Œnothera cæspitosa*) and *Gaura coccinea* also in flower, as well as several composite species.

What has been said of the Missouri and Yellowstone will apply to the plains north of the former river, even to the Saskatchawan region. In the able report of G. M. Dawson on the geology of the forty-ninth parallel, it is shown that the indications of the advance of the season on the Red River (97° longitude), where it intersects the

forty-ninth parallel coincide with those of Cumberland House (latitude 54°, longitude 102°.20), which lies over 300 miles farther north. At Carleton House (latitude 52°, longitude 106°.15) the spring is a week in advance of that in the Red River Valley. At Fort Edmonton (latitude 53°.31, longitude 113°.17), in the foothills of the Rocky Mountains, the spring is also a few days earlier than in the Red River Valley.

The influence of latitude on the early development of plants seems specially perceptible in this zone. Traveling up the Red River from Pembina to Fargo, in May, 1876, I noticed hourly the manifest progress of the vegetation along the banks. I estimated that the advance of Fargo over Pembina was not less than two weeks, or about one week for each degree of latitude, the mean annual rise of temperature for the same distance being 3°, or 1°.5 Fahr. per degree of latitude.

The annual means of Fargo and Benton (uncorrected) are respectively 37°.2 and 44°.4, a difference of 7°.2. Assuming, as we may, that the vegetation between those two points is affected by increased temperature in about the same ratio as between Pembina and Fargo, it follows that Benton is more than a month in advance of Fargo, a fact made manifest not at Benton itself, which is destitute of tillable lands, but on the beautiful prairies which extend thence to the mountains. Over these prairies large herds of cattle roam in complete freedom summer and winter, and by their rapid increase prove the adaptability of land and climate to the successful raising of stock.

Before closing these remarks on temperature I wish to notice an interesting application of a well-known meteorological law. It has been ascertained that the loss of heat by radiation, specially nocturnal radiation, is greater near the ground than at a certain elevation; in other words, we find that within a limited altitude the temperature of the air increases as we rise above the earth's surface. Thus, if two thermometers, placed one on the ground and the other at a height of 150 feet, be read at the same time, the latter would be 12° higher than the former. This increase is noticeable to a height of at least 200 feet. Beyond it, temperature declines with altitude.

In accordance to this law, everybody on the plains may have observed in the early spring that vegetation is more advanced on the slopes and ridges than on bottom lands and low prairies. On high grounds the earliest flowers are found. The farmers on the eastern base of Pembina Mountain begin plowing and sowing at least ten days before those of the Red River Valley. I have also been much annoyed by mosquitoes in May on buttes, where none were seen a few hundred feet away in the low valley. This law, applicable to the surface accidents of one locality, has, if any, but a very limited influence upon the rise of temperature westward on the same parallel.

Rainfall.

On large level areas stripped of forests, the rainfall is generally small and subjected to many variations, which render statistics difficult of interpretation. For instance, at Fort Buford the fall for the year 1872-'73 was more than double that of previous and subsequent years; again, at Fort Benton the mean for the four years ending June, 1874, is 11.42 inches, while that for the three years ending December, 1878, is 17.61 inches. A mean of many years would be required to arrive at correct results. In the absence of sufficient data I can only aim at relative accuracy.

The necessary amount of rain which will enable farmers to raise profitable crops, without irrigation or heavy dews, on fair soil, can be set down at 35 inches, the average of Ohio and Illinois. The mean average of this region is very small, probably not over 15 inches. This small amount, in spite of many fertile valleys and rich prairie lands, will, I fear, always condemn it to the comparative sterility of the Great American Desert.

By comparing observations as near as possible for the same period of years, it is pretty well established that the fall of rain lessens as we proceed westward from the lakes. At Duluth, Minn., it is only 32.2 inches. It does not sensibly decline in wooded districts as far as the Mississippi; thus, it is 33 inches at Brainerd and 28 inches at Saint Paul.

Forest lands end at Detroit, Minn., on the Northern Pacific Railroad, and there the treeless plains may be said to begin. Thereafter arboreal vegetation is limited to the shores of streams and to mountains, and rainfall decreases correspondingly with it.

From the Mississippi to the Red River the decline is quite perceptible: Fargo, 21.5; Wadsworth, 24; and continues to the Missouri: Jamestown, 18.5; Totten, 16.7. On the Missouri and westward to the Rocky Mountains the mean is still lower, and apparently quite insufficient for remunerative farming, as the table exhibits:

	Inches.
Fort Lincoln, Dak	15
Fort Rice, Dak	12
Fort Sully, Dak	16.4
Fort Stevenson, Dak	13
Fort Buford, Dak	12
Fort Benton, Mont	11.4

Fort Keogh, Mont	13
Fort Shaw, Mont	6.7
Fort Baker, Mont	9.[illegible]
Fort Ellis, Mont	16
Fort Lapwai, Idaho	14.[illegible]
Cape Disappointment, Wash	56.[illegible]

It seems that, in a general way, the rainfall grows smaller as we near the Rocky Mountains. It does not increase much, if any, in Idaho, but becomes very large on the Pacific coast. I have ascertained though, without direct statistics, that the precipitation on the Yellowstone is materially larger than on the Missouri for the same meridian.

A small fall equally distributed throughout the year would be of little benefit to the farmer: fortunately for this region, the rain falls mostly in the spring and early summer, from April to July, so as to concentrate its beneficial effects to the season of growth. From Duluth to the Missouri, May, June, and July are the rainy months: west of the Missouri the rainy season is a little earlier, May being the month of greatest precipitation; west of the mountains it is earlier still.

In this region of sandy, porous soil a few inches of rain are far more precious than a few degrees of heat, and we find the most remunerative crops there where the precipitation is largest, viz, east of the Missouri. There is a striking difference in the flora of the two sides of the Missouri where it is crossed by the Northern Pacific Railroad. On the eastern shore the cottonwood disappears; the prairie wears a new aspect, caused by a greater variety of non-gramineous plants and the absence of Buffalo grass.

On James River the timber is mostly elm and box-elder; on the Red River, oak, ash, elm, aspen, and box-elder. No cottonwood grows on either of these streams.

East of Jamestown the soil is more substantial, and the rain, though not averaging 20 inches, falling when most needed, seems sufficient to raise good crops. In the last three or four years the Northern Pacific Railroad, between Jamestown and Red River, has become lined on both sides with flourishing villages, where excellent wheat is raised on extensive tracts of prairie lands.

It is noteworthy that the rainfall has much increased of late over the whole Missouri Basin, and great encouragement thereby given to settlers. I am unable to explain this increased precipitation; being very general, it cannot be due to the cultivation of very limited areas in Dakota and Montana: I fear it does not depend upon permanent causes, and that the last few years of relative abundance will be followed by a period of drought and sterility.

RANUNCULACEÆ.

(Crowfoot family.)

Ranunculus aquatilis, L. (White Water Crowfoot).—Middle Yellowstone: common in swamps: July.

R. Pensylvanicus, L. (Bristly Crowfoot).—Cedar Creek; Crow Agency: July and August.

R. abortivus, L. (Small-flowered Crowfoot).—Tributaries of Middle Yellowstone.

R. Cymbalaria, Pursh. (Seaside Crowfoot).—Tributaries of Middle Yellowstone: Milk River: May.

Clematis ligustifolia, Nutt. (Western-Virgins'-Bower).—Missouri: Cedar Creek: Mouth of Big Horn: Big Rosebud: July.

C. ligusticifolia, var. *brevifolia*, T. and G.—Pompey's Pillar. August, in fruit.

Anemone patens, L., var. *Nuttalliana*, Gr. (Pasque-Flower).—Common on the Northern Pacific Railroad; first seen in blossom on April 15: the earlier flower on the prairies: sparse from Fort Lincoln to Fort Buford: May.

A. Virginiana, L. (Virginian Anemone).—Shoshone Mountains. September, past flowering.

A. cylindrica, Gr. (Long-fruited Anemone).—Cedar Creek, July: Crow Agency, August, in fruit.

A. multifida, D. C. (Many-cleft Anemone).—Judith Basin; September, in seed.

A. Pensylvanica, L. (Pensylvanian Anemone).—Missouri River near Buford, June.

Thalictrum purpurascens, L. (Purplish Meadow Rue).—Cedar Creek, July; Fort Assinaboine, May.

Delphinium exaltatum, Ait. (Tall Larkspur).—Foot of Shoshonee Mountains. September in flower and fruit.

D. Menziesii, D. C.—Cedar Creek. June.

D. bicolor, Nutt. Upper Missouri and Milk River. May.

PAPAVERACEÆ

(Poppy Family.)

Argemone hispida, Gr. Near Porcupine Creek in gravelly plain. August Handsome, showy, white petals.

CRUCIFERÆ.

(Mustard Family.)

Sisymbrium canescens, Nutt (Tansy Mustard).—Very common on the plains; Milk River.

S. linifolium (*S. junceum*, Bieb).—Sandy Blufts of Cedar Creek. July.

Arabis Drummondii, Gr.—Meadows of Middle Yellowstone; May.

A. Halbaellii.—Middle Yellowstone; Missouri Falls; May.

Vesicaria alpina (Dwarf-bladder-pod.)—Common on prairies about Fort Berthold; May.

V. Ludoviciana, D. C.—Upper Missouri; Missouri Falls: May.

Draba caroliniana, Walt.—Sunday Creek; July, seeds shedding.

D. nemorosa, L.—Fort Assinaboine and Milk River; May.

Lepidium intermedium, Gr.—Very common on low prairies; Missouri; Cedar and Sunday Creeks.

Erysimum parviflorum, Nutt.—Missouri Falls. May, first blossoms.

E. asperum, D. C. *var. Arkansanum*, Nutt (Western Wall-flower).—Sunday Creek, June; prairies of Milk River, May.

Nasturtium palustre, D. C. (March Cress).—Crow Agency; August.

Barbarea vulgaris, R. Br. (Common Winter Cress).—Middle Yellowstone.

Stanleya pinnatifida, Nutt.—Bluffs of Cedar Creek, July. Rare.

Thelypodium integrifolium, Endl.—Clark's Fork. September 1, *in flower*.

CAPPARIDACEÆ.

(Caper Family.)

Cleome integrifolia, T. and G.—Common on bad lands of Sunday Creek, July, and bottom lands of Clarke's Fork. September, in fruit.

Polanisia trachysperma, T. and G.—On bad lands of Sunday Creek, July. Much rarer than preceding.

VIOLACEÆ.

(Violet Family.)

Viola Canadensis, L. (Canada Violet).—Lower Yellowstone, June; Milk River and Fort Assinaboine, May.

V. Nuttallii, Pursh.—Missouri bottom. near Fort Buford; Bluffs of Upper Missouri. One variety, with cordate leaves, like the venosa of S. Watson, near Benton. May.

HYPERICACEÆ.

(St. John's-wort Family.)

Hypericum Canadense, L. (Canada St. John's wort).—Crow Agency; August.

CARYOPHYLLACEÆ.

(Pink Family.)

Cerastium arvense, L. (Field Chickweed).—Common on Yellowstone, Milk River, and Fort Assinaboine. May.

C. alpinum, var. *Behringianum*.—Upper Yellowstone.

Arenaria congesta, Nutt. var. *sub congesta*, Watson.—High prairies of Milk River; May.

A. Capillaris.—Middle Yellowstone.

Silene Menziesii, Hook.—Clark's Fork: Milk River.

Lychnis Drummondii, Watson.—Banks of Big Rosebud. August 30, flowers fading.

MALVACEÆ.

(Mallow Family.)

Malvastrum coccineum, Gr. (False Mallow).—Very common on the plains of the Middle Yellowstone; opens in June its showy, pink flowers.

LINACEÆ.

(Flax Family.)

Linum perenne, L. (Wild Flax).—Abounds on sandy, gravelly plains and ridges of the Yellowstone and its tributaries. Blossoms in June.

L. rigidum, Pursh.—Also very common on sandy plains of Yellowstone. Blossoms in June and July.

L. ———.—Rarer form than preceding, but found in some localities somewhat larger and more spreading. Stem more slender; leaves rigid, more strictly linear. Styles divided to the middle, and divergent. Flowers appearing successively, only 1 to 2 at a time; large, 1' in diameter. Petals not spotted at base, mucronate. Possibly only a variety of the preceding.

GERANIACEÆ.

(Geranium Family.)

Geranium incisum.—Banks of Big Rosebud; August, past flowering.

ANACARDIACEÆ.

(Sumach Family.)

Rhus toxicodendron, L. (Poison Ivy).—Missouri, Musselshell, Sunday Creek, Fort Assinaboine; July.

R. aromatica, var. *trilobata*, Gr. (Fragrant Sumach).—First seen on Cedar Creek, thence common north and west on rocky bluffs. Fort Assinaboine.

VITACEÆ.

(Vine Family.)

Vitis cordifolia, Michx. (Winter or Frost Grape).—Missouri Valley, common; Yellowstone, at mouth of Big Horn.

Ampelopsis quinquefolia, Michx. (Virginian Creeper).—Missouri Valley, uncommon.

CELASTRACEÆ.

(Staff-tree Family.)

Celastrus scandens, L. (Climbing Bitter-Sweet).—Missouri, at Fort Lincoln and near Fort Buford.

ACERINEÆ.

(Maple Family.)

Megundo aceroides, Mœnch (Ash-leaved Maple—Box-Elder).—Common on the tributaries of the Missouri, Yellowstone, and Milk Rivers. The prevalent tree on Beaver and Box-elder Creeks, and other tributaries of Milk River.

POLYGALACEÆ.

(Milkwort Family.)

Polygala alba.—Custer Creek, June. Common on the lower prairies.

LEGUMINOSÆ.

(Pulse Family.)

Lupinus perennis, L. (Wild Lupine).—Lower Yellowstone, May.

L. pusillus, Pursh.—Sandy ridges of Sunday Creek, July.

L. Argentens, Pursh.—Headwaters of Clark's Fork, at the foot of mountains; September; a large and handsome species.

L. Ornatus, Dougl.—Gravelly bluffs of Sunday Creek, July 1; in flower and seed.

Psoralea esculenta, Pursh. (*Pomme de prairie*; Prairie Turnip).—Found sparsely on all sandy plateaus. Sunday Creek, June. Edible farinaceous root.

P. argophylla, Pursh.—Cedar Creek; July.

P. floribunda, Nutt.—Cedar Creek: July.

P. lanceolata, Pursh.—Porcupine Creek, August, in blossom and fruit.

Petalostemon violaceus, Michx. (Red Prairie Clover).—Sunday Creek, July. Common.
P. violaceus, var. *mollis*, Gr.—New variety. Stems and leaves clothed with soft, silky pubescence. Willow Creek (between Yellowstone and Musselshell Rivers), August 22.
P. candidus, Michx.—Clark's Fork, September 1.
Glycyrrhiza lepidota, Nutt. (Wild Liquorice).—Abounding on bottom-lands and gravelly plains. One of the most common weeds of this region. Blossoms in July.
Astragalus Canadensis, L. (Canada Milk-Vetch).—Crow Agency, August.
A. caryocarpus, Ker. (Ground Plum).—Common on dry, sandy plateaus. Blossoms early in May. Fleshy pods grown and edible in July.
A. triphyllus, Pursh.—Common on prairies of the Middle Yellowstone and Upper Missouri. Pretty species, blossoming in June.
A. pectinatus, Dougl.—Bluffs of Sunday Creek.
A. flexuosus, Dougl.—Prairies and bluffs of Middle Yellowstone.
A. multiflorus, Gr.—Prairies and bluffs of Middle Yellowstone.
A. adsurgens, Pall.—Prairies and bluffs of Middle Yellowstone.
A. Missouriensis, Nutt.—Prairies and bluffs of Middle Yellowstone.
A. bisulcatus, Gr.—Prairies and bluffs of Middle Yellowstone.
A. Purshii, Dougl.—Prairies and bluffs of Middle Yellowstone.
A. Drummondii, Dougl.—Prairies and bluffs of Middle Yellowstone.
A. Kentrophyta, Gr.—Prairies and bluffs of Middle Yellowstone.
A. Caespitosus, Fr.—Prairies and bluffs of Middle Yellowstone.
Oxytropis Lamberti, Pursh.—Common on bluffs of Middle Yellowstone. Showy, variable species, blossoming in June and July.
O. campestris, L.—Yellowstone. Bluffs of Upper Missouri, May. One of the earliest showy plants of the family.
Hedysarum Mackenzii, Rich.—Cedar Creek, July 12; in flower and seed.
H. Mackenzii, var. *canescens*, Gr.—Cedar Creek, July 12; in flower and seed.
Vicia Americana, Muhl.—Common on banks and prairies of Missouri and Milk River.
Var. *linearis*, Banks of Upper Missouri.
Lathyrus ornatus, Nutt.—Missouri bottom at Fort Buford.
Thermopsis rhombifolia, Nutt.—Missouri bottom and Lower Yellowstone. Showy yellow flowers, opening early in May.
Hosackia Purshiana, Benth.—Missouri, near Fort Berthold, November; seed shedding.
Amphicarpaea monoica, Nutt. (Hog Pea Nut).—Banks of Missouri, near Buford, June.

ROSACEÆ.

(Rose Family.)

Prunus Virginiana, L. (Choke Cherry).—Common in the Missouri Valley as far as the falls and on the Yellowstone west and north of Cedar Creek. Blossoms in May; fruit ripe in August.
Agrimonia Eupatoria, L. (Common Agrimony).—Cedar Creek, June.
Geum album, Gmelin (White Avens).—Cedar Creek, July; Big Rosebud, August.
G. macrophyllum, Willd.—Cedar Creek, July.
G. triflorum, Pursh.—Shoshone Mountains, September, past flowering; Milk River, May.
Potentilla fruticosa, L. (Shrubby Cinque-foil).—Shoshone Mountains and Judith Basin, September.
P. Norvegica, L.—Cedar Creek, July.
P. Pensylvanica, L.—Yellowstone, May, July.
P. gracilis, Dougl.—Cedar Creek, July.
P. gracilis, var. *rigida*, Watson.—Cedar Creek, July.
P. paradoxa, Nutt.—Cedar Creek, July.
P. anserina, L. (Silver Weed).—Fort Assinaboine, May.
Fragaria Virginiana, Ehrhart (Strawberry).—Scattered in valley of Upper Missouri; Carroll, May.
Cratægus tomentosa, L., var. *mollis*, Gr. (Black or Pear Thorn).—Missouri Valley and Fort Buford, May.
C. Douglasii, Lind.—Cedar Creek, July; Judith Basin, September; in fruit. Edible, punctated berry.
Amelanchier Canadensis, T. and G. (June-Berry; Pemmican-Berry).—Sparse on the Missouri (var. *rotundifolia*, Gr.). Headwaters of Cedar Creek, July; fruit nearly ripe. Edible berry; sometimes an ingredient of pemmican.
Rosa blanda, Ait. (Early Wild Rose).—Abounds on all bottoms. Very variable; probably several varieties; needs revision.
Heuchera parviflora, Nutt. (Alum-Root).—Bluffs of Milk River, May.

SAXIFRAGACEÆ.

(Saxifrage Family.)

Ribes floridum, L. (Wild Black-Currant).—Cedar Creek; Crow Agency; August, fruit ripening.

R. lacustre, Poir.—Cedar Creek, June; Musselshell, August; in fruit.

R. setosum, Dougl. (Prickly Gooseberry).—The prevalent gooseberry on the Upper Missouri; blossoms in April, fruit ripe in June; Milk River.

R. aureum, Pursh. (Missouri Currant).—Cedar Creek; Musselshell, August: fruit ripening.

R. cereum, Dougl.—Shoshone Mountains, September; Little Rocky Mountains, October; in fruit: Milk River.

R. irriguum, Dougl.—Foot-hills of Shoshone Mountains, September 10; berries ripe and very palatable.

Parnassia palustris, L.—Clarke's Fort Cañon, September: past flowering.

CRASSULACEÆ.

(Orpine Family.)

Sedum Stenopetalum, Pursh.—Shoshone Mountains, September.

ONAGRACEÆ.

(Evening-Primrose Family.)

Œnothera biennis, L. (Common Evening Primrose).—Common; Cedar Creek, July.

Œ. albicaulis, Nutt.—Open prairie, sparse from the Muscle shell to Fort Lincoln.

Œ. pinnatifida, Nutt.—The most common as well as the most showy Œ. of this region. Alkali bottoms, sandy ridges, bad-lands. Radical leaves tapering into long petioles: stigmus much shorter than the versatile anthers; capsules 1½ inches long; seeds 2-rowed in each cell; fusiform, ½ to 1 inch long, minutely reticulated. Blossoms in June and July.

Œ. cæspitosa, Nutt.—Common in gravelly buttes and bad lands. Sunday Creek, July; Milk River, May.

Œ. serrulata, Nutt.—Rocky Bluffs. Head of Sunday Creek, June.

Epilobium augustifolium, L. (Great Willow-Herb).—Head of Cedar Creek, July: Willow Creek (north tributary of Yellowstone), August.

E. coloratum, Muhl.—Willow Creek, August.

E. paniculatum, Nutt.—Willow Creek, August 22; in flower and seed.

Gaura coccinea, Nutt.—Common on Cedar Creek, and other tributaries of the Middle Yellowstone. Blossoms in June.

G. parviflora, Dougl.—Pompey's Pillar, August; mouth of Big Horn, August; in flower and seed.

LOASACEÆ

(Loasa Family.)

Mentzelia lævicaulis, T. and G.—Near Pompey's Pillar, August 13; near Fort Buford, November 1, in seed: stem and leaves rough-scabrous, viscid-sticky: petals, 5, deep sulphur-yellow, 2 to 3 inches long. Bracteoles inserted in calyx-tube, pinnatifid: seeds in 3 rows (16 in each row), winged.

M. nuda, T. and G.—Bluffs at the mouth of Sunday Creek, August 1, showy plant.

CACTACEÆ.

(Cactus Family.)

Opuntia Missouriensis, D. C. (Prickly Pear; Missouri Cactus).—Abounds on Middle and Lower Yellowstone. Less common on the Missouri.

Mamillaria vivipara, Haw. (Turk's Head).—Same localities, but less common than preceding.

CUCURBITACEÆ.

(Gourd Family.)

Echinocystis lobata, T. and G. (Wild Balsam Apple).—Missouri bottom at Fort Stevenson, May 10, not yet in flower.

UMBELLIFERÆ.

(Parsley Family.)

Sanicula Marylandica, L. (Maryland Sanicle).—Head of Cedar Creek, July.
Heracleum lanatum, Michx. (Cow Parsnip).—Head of Cedar Creek, July.
Cicuta maculata, L. (Spotted Hemlock).—Head of Cedar Creek, July.
Thaspium trifoliatum, L. (Meadow Parsnip).—Fort Stevenson; Judith Basin, September; in seed.
Bupleurum ranunculoides.—Missouri Valley.
Musenium divaricatum, Nutt.—Missouri Valley.
Peucedanum villosum, Nutt.—Bluffs of Upper Missouri; coal banks; May.
P. macrocarpum, Nutt.—Upper Missouri Valley: Benton, April and May; generally found in blossom with the next.
Cymopterus glomeratus, D. C.—One of the earliest flowers of the Middle Yellowstone and Upper Missouri; April and May; common.

CORNACEÆ.

(Dogwood Family.)

Cornus stolonifera, Michx. (Red Osier Dogwood).—Common on bottom lands; July.

CAPRIFOLIACEÆ.

(Honeysuckle Family.)

Symphoricarpus occidentalis, R. Brown (Snow Berry).—Abounding in most valleys.
S. vulgaris, Michx. (Coral Berry).—Cedar Creek, July.
Viburnum lentago, L. (Sweet Viburnum).—Missouri, at Fort Lincoln, June.

RUBIACEÆ.

(Madder Family.)

Galium boreale, L. (Northern Bedstraw).—Cedar Creek, July.
G. triflorum, Michx. (Sweet-scented Bedstraw).—Cedar Creek, July.

COMPOSITEÆ.

(Composite Family.)

Achillea millefolium, L. (Common Yarrow or Milfoil).—Very common in valleys and open prairies. Large form, 1½-3° high. Blossoms in July.
Artemesia cana (White Sage-Brush).—The most common sage-brush of this region.
A. tridentata, Nutt. (Common Sage-Brush).—Common west of Sunday Creek.
A. trifida, Nutt.—Found with the latter, but much rarer.
A. frigida, Willd.—Abundant on gravelly plateaus.
A. biennis, Willd (Biennial Wormwood).—Very common in valleys.
A. Ludoviciana, var. *latiloba*, Nutt.—Judith Basin, September.
A. Canadensis, Michx.—Musselshell River, August.
A. dracunculoides, Pursh.—Musselshell River, August.
Ambrosia trifida, L. (Great Ragweed).—Sunday Creek, August; common in valleys
A. artemisiæfolia, L.—Mouth of Sunday Creek, August.
A. psilostachya, D. C.—Sandy shores of Sunday Creek, at its mouth, August.
Aster falcatus, Lindl.—Clark's Fork, September.
A. lævis, L.—Big Rosebud, August.
A. multiflorus, Ait.—Common; Clark's Fork, September.
Actinella acaulis, Nutt.—Prairies of Upper Missouri and Milk River, May.
A. Richardsonii, Nutt.—Middle Yellowstone.
Anaphalis margaritacea (*Antennaria margaritacea*, R. Brown) (Pearly Everlasting).—Big Rosebud, August 20: conspicuous by its corymbed, pearly, white heads.
Balsamorrhiza sagittata, Nutt.—Bluffs of the Musselshell River, August 16; in seed.
Bahia oppositifolia, T. & G.—Middle Yellowstone.
Bigeloria graveolens, Gr.—Rocky Fork and Clark's Fork, September 1; in flower. A var. on Clark's Fork with smooth stems and leaves.
Crepis occidentalis, Nutt.—Middle Yellowstone.
Cersium undulatum, Spreng.—Head of Cedar Creek, July 12.
Chrysopsis villosa, Nutt (Golden Aster).—Big Rosebud, August 29.
C. villosa, var. *hispida*, Gr.—Big Rosebud, August.
Chænactis Douglasii, H. & A.—Missouri Falls, May 30; not yet in blossom.

Diaperia prolifera, Nutt.—Bad-lands of Sunday Creek, July.
Echinacea augustifolia, D. C. (Purple Cone-Flower).—Common in Missouri Valley, Forts Stevenson and Buford.
Erigeron glabellum, Nutt.—Prairies of Milk River, May 26.
E. strigosum, Muhl. (Daisy Fleabane).—Var. Middle Yellowstone.
E. canescens, Hook.—Missouri Falls, May 30.
E. pumilum, Nutt.—Prairies of Milk River, May 28.
Grindelia squarrosa, Dunal.—Abundant in bottom-lands. Blossoms in July and August.
Gutierrezia euthamiæ, T. and G.—Clark's Fork, September 1.
Gaillardia aristata, Pursh.—Sandy Bluffs of Sunday Creek, June.
Helianthus lenticularis, Dougl. (Western Sunflower).—Very common in the Missouri and Yellowstone Valleys. Blossoms in July and August.
H. Maximilianus.—Musselshell River, August 15; Big Rosebud, August 19.
H. strumosus, L.—Missouri Valley.
Hymenopappus tenuifolius, Pursh.—Yellowstone, Missouri Falls, May 30.
Hieracium Canadense, Michx. (Canada Hawk-Weed).—Big Rosebud, August.
Iva axillaris, Persh.—Mouth of Sunday Creek.
I. Xanthiifolia, Nutt.—Common on Yellowstone.
Kuhnia eupatorioides, L.—Big Rosebud, August.
Liatris punctata, Hook (Punctated Blazing Star).—Very common in open prairies. Blossoms in July to September.
L. scariosa, Willd.—Fort Stevenson, May.
Lepachys columnaris, T. & G.—Cedar Creek, Sunday Creek, July.
L. Columnaris, var. *pulcherrima*.—Porcupine Creek, August.
Lygodesmia juncea; Don.—Very common in low prairies; Sunday Creek, August.
Lactucae canadensis (Wild Lettuce), var. *sanguinea*, T. & G.—Big Rosebud, August.
Macrorrhyneus troximoides, T. & G.—Cedar Creek, July.
Mulgedium pulchellum, Nutt. (False Lettuce).—Common in low prairies. Cedar Creek, July.
Rudbeckia laciniata, L.—Big Rosebud, August.
Salidaga rigida, L. (Golden Rod).—Common in shady spots. Big Rosebud, August.
S. canadensis, L.—Rocky Fork, August.
S. incana.—Rocky Fork, August.
Senecio Canus Hook. (Groundsel).—Yellowstone.
S. integerrimus, Nutt.—Prairies of Milk River, May.
Thelesperma gracile, Gr.—Falls of the Missouri, May 30.
Troximon glaucum, Nutt.—Big Rosebud, August; prairies of Milk River, small form. May 28.
T. cuspidatum, Pursh.—Yellowstone, Upper Missouri, May.
Xanthium strumorium, L. (Common Cocklebur).—Exceedingly common in all bottoms. Porcupine Creek, July.

LOBELIACEÆ.

(Lobelia Family.)

Lobelia Kalmii, L.—Judith Basin, September.

CAMPANULACEÆ.

(Campanula Family.)

Campanula rotundifolia, L. (Harebell).—Sunday Creek, July 3; Clark's Fork, September 2. Common.

ERICACEÆ.

(Heath Family.)

Arctostaphylos Uva-ursi, Spreng. (Bearberry).—Bluffs of Upper Missouri, Little Rocky Mountains, Judith Basin, September 24; berries ripe.

PLANTAGINACEÆ.

(Plantain Family.)

Plantaga major, L. (Common Plantain).—Big Rosebud, August.
P. Patigonica, Jacq., var. *gnaphalioides*, Gr.—Quite common on the low prairies of the Yellowstone.
P. pusilla, Nutt.—Alkali banks of Upper Missouri.

PRIMULACEÆ.

(Primrose Family.)

Lysimachia ciliata, L.—Head of Cedar Creek, July.
L. quadrifolia, L.—Missouri Valley at Fort Stevenson.
Dodecatheon Meadia, L. (American Cowslip).—Dauphine Rapids (Upper Missouri), May 2; Middle Yellowstone, May 26.
Androsace occidentalis, Pursh.—Dauphine Rapids (Upper Missouri), May 2.

AROBANCHACEÆ.

(Brom-rape Family.)

Aphyllon fasciculatum, T. & G.—High prairies at head of Sunday Creek, August 1. Past flowering.
Phelipæa Ludoviciana, Don.—Sandy plateaus of Sunday Creek, August. Common.

SCROPHULARIACEÆ.

(Figwort Family.)

Pentstemon acuminatus, Dougl.—Lower Yellowstone, May. A very handsome species, with sky-blue (purple base) flowers and soft, green, glaucuous leaves; seen in a stunted form along Northern Pacific Railroad, June 8.
P. albidus, Nutt.—Lower and Middle Yellowstone, June; banks of Upper Missouri, May 20.
P. cœruleus, Nutt.—Banks of Upper Missouri, May.
P. Cristatus, Nutt.—Lower Yellowstone, June.
Castilleia sessiliflora, Pursh.—Rocky Bluffs; common on Middle Yellowstone; Milk River, May.
C. affinis, H. & A.—Clark's Fork Cañon, in a mountain brook, September 4; flowers fading.
C. linariæfolia, Benth.—Shoshone Mountains, September 10.
Orthocarpus luteus, Nutt.—Middle Yellowstone.
Mimulus luteus, L. (Yellow Monkey-Flower).—Big Rosebud, August.
Veronica anagallis, L. (Water Speedwell).—Big Rosebud, August.
Synthyris plantaginea, Benth.—Fort Assinaboine (Milk River), May 25, past flowering.

VERBENACEÆ.

(Vervain Family.)

Verbena bracteosa, Michx.—Middle Yellowstone.
V. hastata, L. (Blue Vervain).—Big Rosebud, August.

LABIATÆ.

(Mint Family.)

Mentha Canadensis. L. (Wild Mint).—Very common in low, damp places.
Lycopus sinnosus, Benth. (Water Horehound).—Big Rosebud; Crow Agency; August.
Hedeoma Drummondii, Benth.—Middle Yellowstone.
Stachys palustris, L. (Swamp Hedge-Nettle).—Var. *Cordata*, Gr.—Big Rosebud, August.
Monarda fistulosa, L. (Horse-Mint; Wild Bergamot).—Willow Creek; Rig Rosebud; August.

BORRAGINACEÆ.

(Borage Family.)

Mertensia lanceolata, D. C.—Lower Yellowstone, May.
Echinospermum deflexum, Lehm.—Cedar Creek, July.
E. Redowskii, Var. *Cupulatum*, Gr.—Middle Yellowstone.
Chamærhodus erecta, Bunge.—Yellowstone.
Exitrichium glomeratum, D. C.—Ridges of Lower Yellowstone, May.
E. crassisepalum, Torr.—Lower Yellowstone.
Lithospermum angustifolium, Michx.—Missouri and Yellowstone; common.

L. Canescens, Lehm. (Hoary Puccoon).—Banks of Upper Missouri; common; May.
L. pilosum, Nutt.—Yellowstone.
Heliotropium Curassavicum, L.—Lower Yellowstone, May 25.

HYDROPHYLLACEÆ.

(Waterleaf Family.)

Phacelia Menziesii, Torr.—Yellowstone; Missouri Falls, May 30.
Ellisia ambigua, Nutt.—Common in low, sandy prairies; Sandy Creek, June.
E. Nyctelea, L.—Yellowstone.

POLEMONIACEÆ.

(Polemonium Family.)

Collomia linearis, Nutt.—Bad-lands of Sunday Creek.
Phlox subulata, L. (Ground or Moss Pink).—Very common in the high prairies and bluffs of the Missouri; also found on Yellowstone and Musselshell. Blossoms early in May, when it covers the prairies with its delicate white flowers. This form has white, entire petals.

CONVOLVULACEÆ.

(Convolvulus Family.)

Evolvulus argenteus, Pursh.—Yellowstone.
Calystegia sepium, R. Br. (Hedge Bindweed).—Yellowstone, July; Porcupine Creek.

SOLANACEÆ.

(Nightshade Family.)

Physalis Pennsylvanica, L.—Yellowstone (mouth of Sunday Creek), August.
Solanum rostratum, Dunal.—Sandy slopes of Sunday Creek, July.

GENTIANACEÆ.

(Gentian Family.)

Gentiana affinis, Smith.—Musselshell; Shoshone Mountains; Judith Basin; August and September.
G. barbellata, Eng.—Slopes of Shoshone Mountains, September.
G. Amarella, L.—Judith Basin, September.
Frasera speciosa, Dougl. (American Columbo).—Shoshone Mountains and Judith Basin; September, in seed.

APOCYNACE.

(Dogbane Family.)

Aposcynum cannabinum, L. (Indian Hemp).—Missouri Bottom.
A. androsæmifolium, L. (Spreading Dogbane).—Sunday Creek, August.

ASCLEPIADACEÆ.

(Milkweed Family.)

Asclepias incarnata, L. (Swamp Milkweed).—Musselshell, August.
A. Cornuti, Dec. (Common Milkweed).—Very common; Sunday Creek, Big Horn, and westward.
Acerates decumbens, Dec.—Musselshell, August 10, in fruit.
A. viridiflora, Ell.—Musselshell, August 10, in fruit.

OLEACEÆ.

(Olive Family.)

Fraxinus Americana, L. (White Ash).—High grounds of Missouri bottoms and ravines. From Lincoln to Carroll in small groves. On Yellowstone above Tongue River. Middle-sized tree not very suitable for timber but supplying excellent fuel to steamboats.

NYCTAGINACEÆ.

(Four-o'clock Family.)

Oxybaphus albidus, Sweet.—Sunday Creek, July.

CHENOPODIACEÆ.

(Goosefoot Family.)

Chenopodium album, L. (Lambs Quarters).—Very common on sandy, alkali bottoms.
Eurotia lanata, Mog. (White Sage).—Common on sandy bluffs and bad-lands. Sunday Creek, July.
Suæda Torreyana, Gr.—Bad-lands of Sunday Creek, July.
Monolepis chenopodioides, Mog.—Sunday Creek.
Atriplex patula, L.—Sunday Creek.
Obione confertifolia, Torr.—Common on sandy, alkali ridges; Sunday Creek, July.
O. canescens, Mog.—Sandy bluffs. Sunday Creek, July.
O. argentea, Mog.—Sandy bluffs; Sunday Creek, July.
Corispermum hyssopifolium, L. (Bug-Seed).—Characteristic of bad-lands above and below Fort Peck; October, in seed.
Sarcobatus vermiculatus, Torr. (Grease-Bush).—Common on alkali buttes of Middle Yellowstone; June 25, beginning to blossom.

POLYGONACEÆ.

(Buckwheat Family.)

Polygonum aviculare, L. (Knot-Grass; Goose-Grass).—Sunday Creek, July.
P. aviculare, Var. *erectum*. Roth.—Middle Yellowstone, August.
P. tenue, Michx.—Middle Yellowstone.
P. dumetorum, L. (Climbing False Buckwheat).—Big Rosebud, August.
P. amphibium, L. (Water Persicaria).—Sunday Creek, July.
Rumex salicifolius, Weinman (White Dock).—Sunday Creek, July.
R. venosus, Purch.—Sunday Creek, June; Upper Missouri, May.
Eriogonum annuum, Nutt.—Mouth of Sunday Creek, August.
E. multiceps, Ker.—Bluffs of divide between Yellowstone and Missouri July
E. cernuum, Nutt.—Pompey's Pillar, August.
E. flavum, Nutt.—Bluffs of Middle Yellowstone.
E. umbellatum, Torr.—Shoshone Mountains, September.

ELÆAGNACEÆ.

(Oleaster Family.)

Sheperdia argentea, Nutt. (Buffalo-Berry).—Common on Missouri, Yellowstone, and Musselshell. Blossoms in May; fruit ripe in August, but most palatable in October and November.
S. canadensis, Nutt. (Canadian Sheperdia).—Judith Basin, September 24; no fruit seen.
Olæaguus argentea, Purish. (Silver Berry).—Head of Cherry Creek, July; Judith Basin, September, in fruit.

SANTULACEÆ.

(Sandalwood Family.)

Comandra umbellata, Nutt.—Fort Buford, May. Common on bluffs and prairies of Upper Missouri.

EUPHORBIACEÆ.

(Spurge Family.)

Euphorbia marginata, Pursh.—Mouth of Sunday Creek and Yellowstone, Aug.
E. dictyosperma, Fisher and M.—Yellowstone, August, in fruit.
E. montana, Engelm.—Bluffs of Middle Yellowstone, June.
E. glyptosperma, Engelm.—Bluffs of Middle Yellowstone, June.

URTICACEÆ.

(Nettle Family.)

Urtica gracilis, Art.—Cedar Creek. July.
Humulus lupulus, L. (Common Hop).—Missouri and Yellowstone, Cedar Creek, July.

Ulmus Americana, L. (American or White Elm). High grounds of Missouri Valley. Next to Cottonwood the most common tree below Buford; scarce above Buford; not seen above Peck. Small tree, rarely more than 12 to 18 inches in diameter. Worthless as fuel. Blossoms in April.

CUPULIFERÆ.

(Oak Family.)

Quercus macrocarpa, Michx. (Bur-Oak; Mossy Cup; White Oak).—Missouri Valley, from Fort Stevenson down.

BETULACEÆ.

(Birch Family.)

Betula occidentalis, Hook. (Western Birch).—Clark's Fork, Judith Basin; September, Fort Assinnaboine.

Alnus incana, var. *glanca*, Ait. (Speckled Alder).—Big Rosebud, August.

SALICACEÆ.

(Willow Family.)

Salix cordata, Muh. (Heart-leaved Willow).—The prevalent species on the Missouri. Common on Yellowstone, Musselshell, Big Rosebud, and People's Creek.

S. longifolia, Muhl. (Long-leaved Willow).—Common on Upper Missouri and Yellowstone.

S. discolor, Muhl. (Glaucous Willow).—Big Rosebud, People's Creek.

S. nigra, March. (Black Willow).—Yellowstone, Big Rosebud, Cedar Creek.

Populus monolifera, Ait. (Cottonwood).—Forms the bulk of the timber on all bottoms from the Lower Missouri to the foot of the Rocky Mountains. It extends on the Missouri to Fort Benton; on the Yellowstone, nearly to the cañon; on Milk River, beyond the boundary line. Beautiful tree after attaining a diameter of 6 feet. Supplies steamboats with most of their fuel.

P. angulata, Ait. (Angled Cottonwood).—Found with the latter but much rarer.

P. tremuloides, Michx. (American Aspen).—Headwaters of Big Rosebud and Clark's Fork.

P. angustifolia, James (Willow-leaved Poplar).—Common on the Upper Yellowstone and tributaries, where it replaces the monolifera. First appears on the Missouri above Marais River. Common on Teton and Marais rivers. Found at the Falls of the Missouri. Not seen on Milk River, but no doubt growing on its northern affluents.

P. balsamifera, L. (Balsam Poplar).—Always found with the latter but rarer. A few specimens at Fort Assinaboine.

CONIFERA.

(Pine Family.)

Pinus ponderosa, Dougl. (Yellow Pine; Bluff Pine).—The prevalent pine of this region; a small, stunted form. From the 107° longitude to the Rocky Mountains.

P. flexilis, James (Flexible Pine).—Shoshone Mountains.

Abies Douglasii, Lind.—Shoshone Mountains; bluffs of Upper Missouri. A lofty, handsome tree.

Juniperus communis, L. (Common Juniper).—Var. *Alpina*, L.—Shoshone Mountains; Judith Basin.

J. Virginiana, L. (Red Cedar).—Common on Missouri above the Little Missouri and on Yellowstone westward of Tongue River. High bluffs below the altitude of the pine.

J. Sabina, var. *procumbens*, Pursh. (Savin Ground, or Creeping Cedar).—Very common on rocky bluffs of Missouri and Yellowstone; not seen on the mountains.

TYPHACEÆ.

(Cat-tail Family.)

Typha latifolia, L. (Common Cat-tail).—Lower Missouri

ALISMACEÆ.

(Water Plantain Family.)

Alisma plantago, L. var. *Americanum*.—Swamps near the Big Muddy; Upper Missouri.

ORCHIDACEÆ.

(Orchis Family.)

Habenaria hyperborea, Gr.—Head of Clark's Fork, September.

IRIDACEÆ.

(Iris Family.)

Sisyrinchium Bermudiana, L. var. *mucronatum*, Gr. (Blue-eyed Grass).—Cedar Creek; July in fruit.

SMILACEÆ.

(Smilax Family.)

Smilax herbacea, L. (Carrion-Flower)—Missouri Valley, below Buford.

LILIACEÆ.

(Lily Family.)

Leucocrinum montanum, Nutt. (Prairie Lily).—Lower Yellowstone, June 1; a very pretty ornamental species.

Smilacena stellata, Desf.—Musselshell; Milk River, May.

Calochortus nuttallii, T. & G. (Sego).—Common on the Middle Yellowstone, June.

Fritillaria atropurpurea, Nutt.—Middle Yellowstone and Judith Basin, on broken prairie; a very elegant species; blossoms in May and June; seed ripe in July.

F. pudica, Spreng.—Common on prairies of Judith Basin. In blossom at Dauphine Rapids (Missouri) May 2; in seed at Fort Assinaboine (Milk River) May 20.

Zigadenus nuttallii, Gr.—Common on dry prairies of Yellowstone and Judith Basin.

Z. paniculatus, Watson.—High prairies of Milk River; Middle Yellowstone, May and June.

Allium reticulatum, Fraser. (Reticulated Garlic).—Very common on Upper Missouri and Yellowstone; May, July.

A. cernuum, Roth. (Wild Onion).—Bad lands of Upper Missouri.

Yucca angustifolia, Pursh. (Adam's Needle).—Bluffs of Missouri above Fort Buford. Common on Yellowstone; June, July; fruit ripening in August.

COMMELYNACEÆ.

(Spiderwort Family.)

Tradescantia Virginica, L. (Common Spiderwort).—Sandy plains near Sandy Creek, June.

CYPERACEÆ.

(Sedge Family.)

Scirpus sylvaticus, L.—Missouri Valley.

Carex filifolia, Nutt.—The prevalent sedge on prairies of Milk River, around Fort Assinaboine.

GRAMINEÆ.

(Grass Family.)

Andropogon furcatus, Muhl. (Beard Grass).—Missouri Valley; common.

A. scoparius, Michx.—Open prairies of Missouri and Yellowstone; common.

Aristida purpurea, Nutt.—Buttes near Porcupine Creek, August.

Bouteloua Oligostachya, Torr. (Buffalo Grass).—The prevalent grass of the open prairie, west of the Missouri, July.

B. curtipendula, Var. *aristosa*, Gr.—Mouth of Sunday Creek, Upper Missouri, July.

Bromus ciliatus, L.—Bid Rosebud, August.

Beckmannia erucaformis, Host.—Big Muddy, Missouri Valley.

Buchloe sesleriovides.—Sunday Creek, Yellowstone.

Brizopyrum spicatum, Hook.—Sunday Creek, Yellowstone.

Calamagrostis longifolia, Hook.—Yellowstone and Missouri.

C. sylvatica, D. C.—Mouth of Sunday Creek, Yellowstone Valley.

C. stricta, Trin.—Yellowstone Valley.

Elymus Canadensis, Beauv.—Very common on the Yellowstone, Missouri Valley.
E. sitanion, Shult.—Common on Sunday Creek and other tributaries of Middle Yellowstone.
E. condensatus, Presl.—Yellowstone.
Eragrostis poæsides, Beauv., var. *megastachya*, Gr.—Yellowstone.
Eleocharis acicularis, Br.—Yellowstone.
Eriocoma cuspidata, Nutt.—Very common on the plateaus of the Yellowstone region.
Hordeum pratense, Huds.—Common on bottoms and slopes.
H. jubatum, L. (Squirrel-tail Grass).—Common on bottoms and slopes.
Lepturus paniculatus, Nutt.—Yellowstone.
Muhlenbergia glomerata, Trin.—Big Rosebud, August 30.
M. Mexicana, Trin.—Big Rosebud, August 30.
Munroa squarrosa, Torr.—Yellowstone.
Poa. tenuifolia, Nutt.—Prairies of Upper Missouri and Milk River.
Phalaris arundinacea, L. (Reed-Canary Grass).—Missouri and Yellowstone Valleys.
Phragmites communis, Trin. (Common Reed).—Common in swamps of Missouri Valley.
Stipa comata, Trin. (Porcupine Grass).—Very common on the plateaus of the Yellowstone region, west of Custer Creek. Blossoms in June. From July to October a very troublesome grass, the seeds adhering by their barbed-pointed base to everything they touch.
S. spartea, Trin.—Prairies of the Missouri.
S. viridula, Trin.—Sparse on Yellowstone and Missouri prairies.
Spartina cynosuroides, Willd.—Missouri bottom.
S. gracilis, Trin.—Sunday Creek, July.
Sporobolus airoides, Torr.—Low prairies of Yellowstone.
S. ramulosus, Kth.—Low prairies of Yellowstone.
Triticum repens, L. (Quick-Grass).—Abundant all over this region. Sunday Creek, July. In places gives a bluish tinge to the prairie.
T. ægilopoides, Turcz.—Missouri Valley.
T. violaceum, Horn.—Yellowstone and Missouri.
Vilfa cuspidata, Torr.—Yellowstone and Missouri.

HEADQUARTERS DEPARTMENT OF DAKOTA,
CHIEF ENGINEER'S OFFICE,
Saint Paul, Minn., April 7, 1880.

SIR: I have the honor to submit the following report, showing the duties performed by me during the past summer. Results of observations for meridian, altitude, and latitude, and such other information as I considered would prove useful to the Engineer Department, are respectfully appended.

Paragraph 2, Special Orders, No. 58, Headquarters Department of Dakota, Saint Paul, Minn., dated June 2, 1879, a copy of which is hereunto appended, directed me to proceed to Fort Custer, Mont., and make a survey of the proposed military reservation of that post, and written instructions from the chief engineer of the department directed me on the completion of that duty to make a survey of Custer's battle-ground and Fort C. F. Smith, Mont., with a view of reserving certain lands as a national cemetery and limestone reservation, respectively. A plan of the post of Fort Custer was also directed to be made.

Paragraph 2, Special Orders, No. 58, directed First-class Private Thomas Culligan, Company A, Battalion of Engineers, to proceed with me, and the chief engineer of the department assigned him to duty as my assistant, in which capacity he rendered faithful and efficient service.

Leaving Saint Paul, Minn., June 2, 1879, we traveled without any delay to Big Horn Depot, Mont., arriving there June 19. This cantonment was occupied at that time by Company F, Eleventh Infantry, under command of Capt. Ogden B. Read. There being no transportation available, Captain Read telegraphed to Fort Custer, and the commanding officer of that post, Lieut. Col. A. G. Brackett, Second Cavalry, sent an ambulance to transport us and the instruments to Fort Custer, where we arrived June 23.

Active preparations for a campaign were being made at the time of our arrival, and all the available transportation at the post was required to accompany the expedition. It was not until August 1 (the date of the arrival of two wagons ordered to Custer from Keogh by the department commander for the use of the engineer party) that I was enabled to enter upon the survey of the reservation.

The time intervening was occupied in taking observations for the time, ascertaining the meridian, and making a survey of the post of Fort Custer. The instruments used during the surveys were as follows:

One transit, No. 830, Blunt & Co., New York.
One level, W. & L. E. Gurley, Troy, N. Y.
One chain, 100 feet, No. 12, W. & L. E. Gurley, Troy, N. Y.
One sextant, No. 6536, Spencer, Browning & Co., London.
One artificial horizon.
One pocket chronometer, No. 1481, R. & H. Molyneaux, London.
One aneroid barometor, No. 1552, L. Casella, London.
One thermometer, mercurial.

Upon the arrival of the wagons, a detail of one non-commissioned officer and nine privates reported to me by order of Capt. G. K. Sanderson, Eleventh Infantry, then the post-commander. The following day, August 2, everything being in readiness, the survey of the proposed reservation was commenced.

General Orders, No. 1, Headquarters Big Horn Post, Mont., dated July 4, 1877, governed the survey, and reads as follows:

[General Orders, No. 1.]

HEADQUARTERS BIG HORN POST, MONT.,
July 4, 1877.

* * * * * * *

2. Until the post be named officially, in orders from higher authority, it will be known as Big Horn Post, and the military reservation pertaining to it is hereby declared as 20 miles square, the center of which will be the flag-staff, the sides running north, east, south, and west.

GEO. P. BUELL,
Lieutenant-Colonel Eleventh Infantry, Commanding Post.

The position of the flag-staff is marked by a large flat stone in the center of the parade-ground, and the meridian having been previously determined, a true west line was run from the center of this stone across the Big Horn River (the width of which was determined by triangulation) to a point 10 miles due west of said center stone.

This point was reached August 4. It is marked by a stake, and is 1,207 feet south of stake on Fort Ellis stage-road, the latter stake measuring 7 feet in length and 5 inches in diameter, being firmly set and marked "U. S. R. Western Boundary."

From the left bank of the Big Horn River this line passed over a dry alkaline bottom, covered at first with balsam, afterwards by sage and prickly pear, to an elevation at 18,900 feet from site of flag-staff; thence across two ravines to a still greater elevation, with soil a little superior and better grass. The telegraph line and stage-road to Fort Ellis pass over this bench about half a mile north of the line, and gradually converging to it; the telegraph line crosses at 39,350 feet, and recrosses at 48,350 feet. The road crosses at 43,040, and recrosses at 50,380 feet.

At 32,500 feet the line led off the elevated ground into a creek valley scored by a network of washouts and water-holes, all dry and cracked at this season.

At 41,500 and 41,900 feet the line crosses water-holes containing alkaline water, and about 200 yards to the right, and opposite a point 43,040 feet from center stone, stands a large water-hole, extending 180 feet in length, with a maximum width of 5 feet, and at this season separated into two portions. These pools are known as Clarke's Pools, or 9 mile pools, and although alkaline they are very acceptable in this thirsty region. Water is to be found always in these pools, and travelers passing over the stage-road rarely pass without resting there.

At 45,700 feet a divide was reached, the highest elevation on the line, not including the site of Fort Custer. From this divide to the western boundary the ground slopes down gradually to a creek bed, which is situated close to the stake marking the western extremity of the base line. This creek has plenty of water in pools, and is lightly timbered with cottonwood and young scrub ash. Its valley is about 600 yards in width, with balsam, rosebushes, and buffalo grass of a superior quality, the principal features. Sage and greasewood are also fairly represented. The valley affords very fine grazing, which the animals appeared to enjoy. As yet no wood was encountered suitable for camping purposes, but in anticipation of such an experience, a supply was taken along from the post.

Turning due south from the stake before mentioned the southern half of the western boundary was run, leading down the creek and crossing it several times. At 5,364 feet the summit of a high ridge of hills was reached, and the boundary was continued over a rough elevated country, fairly grassed to a point 18,000 feet due south of the western extremity of the base line. Thence down a steep pitch to a creek valley, well grassed, with water in pools, slim in quantity and of a very alkaline quality. At 38,000 feet bad lands were encountered, with cone-like elevations, black and bare, smooth and round, and reaching to 41,660 feet, at which point the high rough ground branches away to the right, and rolling, well-grassed prairie entered upon. Water in holes was encountered many times after clearing the hills, the country became more

pleasant and interesting, and the grass plentiful and good. This rolling, pleasant country continued to the southwest corner of the reservation, where a large post, 5 feet long and 9 inches in diameter, was firmly planted in the ground and marked "U. S. R., SW. Cor. 1879."

The corner post stands about midway between the summit and base of a low ridge leading in a westerly direction to the hills beyond, and can be easily found from its proximity to a small patch of timber standing out alone on the prairie about three-fourths of a mile east of a point one-fourth of a mile north of the corner post.

Wood and water sufficient for camping purposes was secured at a point about 3 miles east of the southwest corner.

The southern boundary of the reserve from the southwest corner to the left bank of the Big Horn River passes over a luxuriantly grassed and level prairie, exhibiting no timber whatsoever to the eye save the two patches already mentioned viz, one patch near the corner, the other 3 miles east, and the location of one of our camps.

A road to Fort C. F. Smith (at present unused) was crossed at 12,500 feet due east from the southwest corner, and the high bank of the Big Horn River reached at 20,800 feet. Stakes were established on the boundary line on both banks of the river, that on the right bank being placed and driven by two men of the party who swam the river carrying an ax between them.

While thus occupied the rear flagman, positioned about 3,000 feet behind the transit, deserted his post and ran swiftly towards the party. He reported the close proximity of a party of Indians whom he stated had deliberately fired two volleys at him. A brisk breeze was blowing towards the point indicated as the Indian position, which proved to be the camping place of the previous evening. The fact that none of the party on the river bank heard the shooting may be attributed to this cause. A man mounted on the only saddle-horse in the party was sent out to reconnoiter, and he discovered a party of five Indians galloping up the valley in the direction of the corner post. A few moments later and they became visible to the whole party. No further molestation occurred, and the work of establishing the stakes was completed.

The left bank of the Big Horn River at this point is about 120 feet high and very precipitous, its descent being quite dangerous and difficult, while the right bank is low and sloping to the prairie beyond.

From our elevated position the course of the river could be traced from the Big Horn Cañon to the foot of Far West Island.

From the stake on the left bank of the Big Horn the river was meandered by courses and distances to a stake on the left bank of the river opposite Fort Custer temporarily placed at a point 2,966 feet due west of the center stone of the parade-ground.

From the stake on the southern boundary the high bank continues down for a distance of nearly 5 miles, until a fine running stream with gravelly bed was reached. Here the hills recede from the river, while the river itself, as if unable to travel without some support, seeks the high bluffs on its right, spreading out to a great width in its endeavor, and forming the largest island in the river, named "Far West Island," after the steamer "Far West," which ascended to the foot of the island in 1876, under command of Capt. Grant Marsh. From the crossing of the creek before mentioned the courses were run along the bottom, outside of the timber, as the means at my command would not enable me to make any closer surveys.

Upon our arrival at the post I reported the Indian affair to the commanding officer, Capt. G. K. Sanderson, and at the same time requested that two additional men be allowed to the party. My request was immediately granted, and the party then consisted of 1 non-commissioned officer and 11 privates of the Eleventh Infantry, two civilian teamsters, Culligan, and myself—16 men in all.

August 10.—Returning along the stage-road to Fort Ellis, the stake situated 10 miles due west of the position of the flag-staff was reached, and preparations made to continue the northern half of the western boundary to the northwest corner.

This line leads over a very rolling, hilly country, fairly grassed, and cut up with water courses, all more or less stocked with pools of alkaline water; sage and cactus abundant. At one place on this line, 41,280 feet north of the stake marking the center of the western boundary, very bad alkaline water was encountered, in the immediate vicinity of a bare alkali flat about an acre and a half in extent. This flat is of a dull slate color and perfectly destitute of any vegetation whatever.

At 9 miles and 2,000 feet the line reached the foot-hills at the base of Pine Ridge, a lofty formation and the divide between the Yellowstone and Big Horn rivers. The northwest corner post was set on the eastern slope of this ridge, and about midway between its base and summit, in a pocket mounted on either side by immense masses of rock. West of the corner, 110.2 feet, stands a huge bowlder, which afforded every advantage for use as an indicator of the position of the pine post marking the northwest corner. The post is marked "U. S. R., NW. Cor., 1879," and the bowlder is marked on its southern face with the following inscription: "U. S. R., NW. Cor., 110.2 feet E. See stake [illegible]." The rocky nature of the ground prevented us sinking

the corner-post to a greater depth than 9 inches, but earth and rocks were piled up around the post, rendering it solid and firm.

The bowlder is a permanent landmark, and is visible from the southern approach.

From this corner the boundary extends due east to the left bank of the Big Horn River, which it intersects at a distance of 9 miles 3,307.1 feet. The country it passes over is well watered with gravelly-bedded creeks, which contain good spring water near their sources in Pine Ridge, but whose excellence gradually deteriorates as its distance from the ridge increases. The general description of the country from Pine Ridge to the hills bounding the Bighorn Valley on the west is rolling and fertile, with no timber except the pine on and close to the ridge.

Some prominent landmarks exist along this line, viz, "Boundary Butte," a compact, conical mass, topped with rock 300 feet south of a point 8,500 feet east of northwest corner. A huge bowlder 160 feet south of a point 16,810 feet east of northwest corner. A hill with a huge flat rock protruding, table-like, from its southern face 80 feet north of a point 17,635 feet east of northwest corner.

At 36,730 feet east of northwest corner a ravine is traversed with two springs at its head 10 feet south of the line, the line continuing down the ravine 670 feet to the beautiful valley of a dry creek 900 feet in width, named "The Boulevards," crossing the same near its mouth, and ascending the low ridge overlooking the valley of the Big Horn; thence across a richly-grassed bottom to the river, intersecting the stage-road to Terry's Landing, at 43,447 feet, and the military telegraph line at 45,945 feet from northwest corner.

It may be interesting to note that the needle of the transit while in the vicinity of Boundary Butte became very unreliable and much agitated. Needle readings were only used in recording topographical bearings.

A 7-foot stake was firmly placed on the east side of the stage-road, with the words "U. S. R., Northern Boundary" marked thereon, and a 7-foot post was firmly planted on the left bank of the Big Horn River at its intersection with the northern boundary and marked "U. S. R., Northern Boundary."

From this point the Big Horn River was meandered by courses and distances to the stake on the left bank of the river opposite Fort Custer.

A ranch, occupied by a man named Wiedman, is situated in a bend of the river about 3 miles below the fort. It is surrounded by fertile meadow land, which, at the time we passed through, was yielding a second crop of hay fully nine inches in length. His garden was also very promising and good.

Clarke's and Ramsey's ranches are situated on the west side of the river close to the ferry crossing. Ramsey keeps a dairy, and furnishes milk and butter to the inhabitants of the fort.

Having completed the survey of that portion of the proposed reservation lying on the west side of the Big Horn River, the party and wagons were transferred to the east side, and after receiving the necessary supplies we traveled over the eastern road to Fort Smith, and encamped on the Big Horn River near the stake established August 6. This point was reached August 16. A large camp of Crow Indians kept us company, and occasioned us any amount of annoyance. The width of the river was determined by triangulation, and the southern boundary continued over the meadow bottom on the east side of the river to the hills forming its eastern boundary, thence over an exceedingly rough and hilly section to the divide between the Big Horn and Little Big Horn rivers.

The Fort Smith road is intersected at 27,760 feet east of southwest corner where a stake is set and marked "U. S. R., Southern Boundary." From the summit of the divide 52,154 feet from southwest corner, a fine view was obtained of the country towards the Little Big Horn. No more rough country, but a gradually sloping and well-grassed rolling prairie. Some dry water-courses were crossed, and a dry creek, in the valley of which some cottonwood is visible. The Little Big Horn was reached at a distance from the southwest corner of 81,580 feet or 15¼ miles nearly, and from the Big Horn River of 11¼ miles nearly. The Fort McKinney stage-road was intersected at 80,024 feet, and a sharp hill on the left bank of the river at 80,569, where a post was established and marked "U. S. R., Southern Boundary, Military Reserve." The words "Military Reserve" were added to distinguish this boundary mark from other stakes in the vicinity, it being evident that the southern boundary would pass close to Custer's Monument and through the proposed national cemetery.

As yet on the southern boundary no sage had been met with, the ground being fertile and well grassed. The rough country west of the divide between the rivers is fairly grassed, with the exception of some elevations near the divide which are totally devoid of vegetation.

Through the timber on the left bank of the Little Big Horn a passage 300 feet in length was cleared, and the river being only 123 feet wide the measurement was made by chain and rope made fast together, and the boundary continued over the valley on the east side of the river to the bluffs made famous by the battle of June 25, 1876.

The Little Big Horn is thickly timbered and has a swift current of excellent water.

In high-water certain fords have to be used, while at this season the river may be crossed almost anywhere.

At the point where we encamped 7 feet of water was discovered, while a few yards above and below, the river flowed over a firm gravelly bottom at an average depth of 14 inches. Catfish and pike were caught in goodly numbers. Fresh bear tracks were discovered on the bank of the river near camp. Bullberries and choke-cherries of a superior quality were discovered in great abundance.

The valley of the Little Big Horn River is one continuous rich meadow. From the bluffs forming the eastern boundary of the bottom to the southeast corner the country is rough and dry, and the line leads over many prominent ridges.

The highest elevation on the east side of the Little Big Horn was reached at 102,952 feet, or about half a mile from the stake marking the southeast corner. This hill is easily distinguished from the stake on the knoll near the McKinney road. The southeast corner is situated on the brow of a small hill about 3 miles west of the pine ridge to the east of the Little Big Horn River, and 600 feet from the creek flowing into that river below the battle-field. This creek is known as Yates Creek.

A post 8 feet long and 7 inches in diameter was established and marked "U. S. R., SE. Cor., 1879," and to distinguish it the words "Military Reserve" were added.

Without including the two rivers, the southern boundary encounters no wood whatever, and water was met with only on one occasion, viz, at the entrance to the broken country on the east side of the Big Horn, the water of that place being very alkaline and undrinkable. A few scattering cottonwood trees are to be found along the banks of Yates Creek, and the creek entering the Little Big Horn from the west, to which allusion was made previously.

Very little game was seen after crossing the Big Horn, and, as yet, none killed by any of the party.

Starting from the southeast corner, the eastern boundary leads over a rough, poor country to the Pine-Ridge Divide between Tullock's Fork and the Little Big Horn River.

Strongly-impregnated alkali pools were found in the bed of Yates Creek, 1,300 feet north of the southeast corner. The water they contained was very bad. The appearance of the country undergoes an immediate and remarkable change from that hitherto traversed. Sage in great quantities covers up the whole surface, and crowds out all other vegetation—the soil strong and dark-colored, dry and alkaline. Gypsum springs are numerous, with a scanty supply of undrinkable water, while the beds of the gulches where they exist are crystalized in the immediate vicinity of the springs.

The summit of the Pine-Ridge Divide was reached after crossing many deep ruts and gulches leading west from the ridge at 20,330 feet from the southeast corner. This divide has a rocky summit, with stunted, thinly-scattered pine, and loose sandy soil. Twenty-one feet west of the crossing, at 20,330 feet north of the southeast corner, is a large sandstone bowlder with the letters "U. S. R." cut deep into its face.

The crossing of the divide opened up to our view a beautiful, well-grassed rolling country, traversed by a fairly-timbered creek with plenty of good water, which finds its way from the well-timbered slope on the east side of the pine ridge. Game plentiful, especially black-tailed deer. Pine, mountain ash, box-elder, and hickory, as well as cottonwood and rose-bushes, are to be found in the valley of this creek, which is one of the headwaters of Tullock's Fork.

A tall pine butte stands to the east of camp, which is situated about one mile north of the divide. The soil of the valley is fertile and the grass very abundant. From this valley the line ascends to the divide between the Big Horn River and Tullock's Fork, the ground becoming quite rough and stony. Numerous beautiful masses and peculiarly-shaped buttes grace this section.

Twin Buttes, a prominent mass stands to the west near the boundary, and at the junction of the three divides.

Farther to the north, and 500 feet east of the line, stands a modest butte, capped with a handsome sandstone formation shaped like a vase or urn, which was named "Abbott's Urn," after a member of the party who had from the beginning of the survey evinced a marked and beneficial interest in the work. This butte is situated immediately on the divide between Tullock's Fork and the Big Horn River, and is visible from the road to Fort Keogh, south of the Yellowstone, which intersects the eastern boundary a short distance farther north. The line crosses the divide again at 53,861 feet, where a beautiful view of the mountainous region lying to the west was obtained. A few scattering pines grow on the divide at this point. The letters "U. S. R." were cut into a bowlder on the summit.

At 56,200 feet the line passes on to the Big Horn slope over a rocky precipice to a slope cut up with numerous deep pine ravines, which held out hopes to the party of obtaining good water. But we were doomed to disappointment, which a careful search for the much-needed element realized. No water can be found on the Big Horn slope of the divide at this season; while on Tullock's slope water is to be found without any difficulty. The Big Horn slope is dry and barren, while just across the divide the

country is beautifully verdant and grassy, the water plentiful and good—a perfect Eden in comparison to the Sahara beyond.

From the high ground east of Twin Buttes that noble peak in Wolf Mountains, called "Wagner's Butte," is plainly visible. It was used as a signal-station before the introduction of telegraphic communication to Forts Keogh and Custer. Our camps, while surveying this line, were invariably made on Tullock's slope, which is fairly timbered with pine, cottonwood, hickory, and ash.

The Little Big Horn Ridge branches away to the west from Twin Buttes, and is perfectly bare of any timber. No game seen except on Tullock's slope.

At 61,320 feet from the southeast corner the line touches the rocky summit of the divide, and the letters "U. S. R." were cut in the face of the rock.

From the last crossing on to the Big Horn slope, the divide presents a precipitous, rocky face towards the west, while towards the east the slope is gradual and well grassed. At 68,500 feet the main divide is again crossed for the last time. Numerous cones of friable sandstone grace its summit and pine timber is plentiful at this point, but not suitable for any practical use. Many places along the line where sandstone bowlders occur, near transit stations, the men of the party, during the brief halts, used their pocket-knives scoring the letters "U. S. R." deep into the rocks, with their names underneath.

At 78,956 feet a spur of the divide was reached, and at 80,826 feet, after cutting away some timber, entered a beautiful and fertile valley draining into Tullock's Fork, well timbered and fairly watered. "Gracie's Butte," a handsome conical formation, capped with rock, stands out prominently in this valley to the east of the divide, and about half a mile west of the boundary. It was named after Miss Gracie Sanderson, daughter of Captain Sanderson, Eleventh Infantry, and from its shape and position forms a prominent landmark in this section. This slope, as usual, furnishes pine and cottonwood, and plenty of good water for camping purposes. From this valley the line leads over a rolling country, scoured by water-courses, leading to Tullock's Fork, which stream now becomes visible to the east. A huge rock is intersected by the line at 90,040 feet from the southeast corner, and the letters "U. S. R." were cut deep into its face. The northeast corner is situated in a pleasant valley near the base of a spur of high hills extending from the Big Horn Divide, and close to the mouth of Smith's Cañon. The corner post was firmly placed, and marked "U. S. R., NE. Cor., 1879."

The main stream of Tullock's Fork flows past at a distance from the corner of about 1½ miles to the east, and bounded on its eastern bank by high mountainous country. From the northeast corner the country on all sides presents a very rough appearance. The northern boundary of Smith's Cañon shuts out approach from the north, and high hills immediately to the west render approach from that direction impossible; the mountainous country east of Tullock's Fork completely blocks the entrance in that direction, and that our wagons are really in this valley is the only convincing proof that the valley could be reached at all by wagon.

From the northeastern corner the eastern portion of the northern boundary was run over the roughest country experienced yet by us. The line leads immediately over a spur of the divide overlooking the beautiful cañon, and continues over pine-covered ridges and deep well watered gulches to the head of the cañon, which was reached at 13,000 feet from northeast corner and the summit of the divide at 16,200 feet.

Smith's Cañon is well timbered with pine. An accident occurred on August 24, the date of the establishment of the northeast corner, which seriously affected the movements of the party. One of the wagons was upset and wrecked, and the teamster, James Smith, had his left leg broken midway between the ankle and knee. Camp was pitched near the scene of the accident, and medical assistance sent for to Fort Custer. Wood was obtainable at camp, and water was carried on pack-mules from a spring about 1 mile distant. A signal fire was kept continually burning on the summit of the highest peak near camp to guide the party returning from Fort Custer. In the mean time the topography of the remaining portion of the northern boundary to the Big Horn River was noted. From the summit of the divide the country between it and the river is one great collection of hills, valleys, and ravines. The hills are generally dotted with pine of a small growth; no water was encountered.

About 2 miles east of the Big Horn the ground loses its very hilly nature, and gently rolling, gradually slopes to the river bank, which is about 50 feet high at that point. The northeast section of the reserve is not practicable for wagons.

The injured teamster was transported from Smith's Cañon (named after him) to Fort Custer, under the care of Hospital Steward J. Rhinehart, and the party reached Custer August 28, and encamped on the Little Big Horn River, about 3 miles above the post.

The only ranchmen on the reserve are the following: Dana, Ramsey, Clarke, and Wiedman. Dana and Ramsey keep dairies and furnish the occupants of the post with fresh butter and milk. From personal experience I am happy to state that better dairy produce than Mr. Dana's I never tasted before nor since. The well-stocked cellars at the post speak volumes for the land in the river valleys as suitable for cultiva-

tion. The great drawbacks common to frontier cultivation exist in this section as well as all others, and was sadly exemplified last summer. A heavy hail-storm passed over the post in June, breaking nearly every pane of glass at the post. The damage to the crops from such a visitation must have been considerable. From August to October the country in all directions seemed to be on fire, and property at no time was safe from its fearful ravages.

The timber within the limits of the proposed reserve may be summed up in a few words, viz, that on the banks of the rivers mainly cottonwood; some pine in the northwest and northeast corners, but insufficient for any practical purposes. The timber used in building the post was procured from Pine Ridge outside the northwest corner of the reserve. The general size of this pine is 35 feet long by 18 inches in diameter. Some measure 55 feet in length and 3 feet in diameter, and some pine trees have furnished each two saw-logs 16 feet in length and one saw-log 12 feet in length.

The pine in the northeast corner of the reservation is not available, the country being so rough and the timber stunted and very much scattered.

Before concluding this report I would respectfully state that the road to Keogh passing through the eastern portion of the reserve is, to say the very best of it, *bad*. Government teams may pass over it, but private owners of stock who hold the health of their animals and the safety of their wagons at heart, and who are acquainted with this route, would, under usual circumstances, never think of traveling over it. The road to Big Horn Depot, crossing the Yellowstone at that point by ferry, and down the left bank of the river, is excellent, remarkably level, and 127½ miles in length. This distance was ascertained from actual odometer measurement taken by me while traveling from Custer to Keogh in September, a list of which is respectfully appended.

CUSTER'S BATTLE GROUND.

The verbal instructions of the chief engineer of the department regarding the survey of Custer's battle ground were as follows:

1st. To ascertain the general direction of that portion of the Little Big Horn River flowing through the proposed reserve.

2d. The reserve to be rectangular, with the eastern and western boundaries parallel, or nearly so, to the general direction of the river.

3d. The northern boundary to pass one mile distant and the eastern boundary one mile distant from Custer's Hill, the western boundary to include the low hills on the west side of the Little Big Horn, and the southern boundary to include Reno's position.

After surveying the river and platting the work the following boundaries were adopted, viz:

From a point (N. 35° W., and one mile distant from the center of Custer's monument) marked "I. P." the boundaries are as follows: N. 55° E., 1 mile; thence S. 35° E., 6 miles; thence S. 55° W., 3 miles; thence N. 35° W., 6 miles; thence N. 55° E., 2 miles, to the place of beginning.

The variation of the needle at Custer's battle ground is 18° 20′ east.

Custer's monument is a pyramidal pile about 10 feet high, composed of bones, and inclosed with logs. It stands on the elevation known as "Custer's Hill." The initial point, 1 mile N. 35° W., is marked by a circular stake, 4½ feet in length and 9 inches in diameter, sunk 2½ feet, with earth and stone packed up to a height of 1 foot. The stake is marked "I. P., U. S. N. C." on the top.

The posts marking the corners of the proposed national cemetery were made especially for the purpose by the post-quartermaster at Fort Custer; painted blue, with black crosses mounted on the top; measuring 12 inches along the staff, and 9 inches beam. The posts, 8 feet long and 8 inches square at the end, were made of pine.

From the monument to the I. P. the line passes down the ridge, rolling and sloping gradually downwards. From the I. P. to the northeast corner the line leads down the eastern slope of the ridge, crosses Yates Creek, and ascends a gentle slope to the corner. The grass is nearly knee deep on this incline.

The corner is marked "U. S. N. C., NE. Cor., 1879. The Custer Battle-Field Nat'l Cem'y."

The eastern boundary, after crossing Yates Creek, ascends a sharp rocky ridge; thence over a rough valley to the high land, reaching it at 9,058 feet from the northeast corner; thence, over a deep chasm with a little running water, to an elevation beyond which is the highest in that section; thence, over a rough, fertile country, to the valley of Reno's Creek, and on to the low divide between Reno's and Benteen's Creeks.

The southeast corner is situated immediately in a ravine. The post marking the position of the corner is situated 316 feet from the corner on the southern boundary, and marked as follows: "U. S. N. C., 1879, SE. Cor., 316 feet N. 55 E. in ravine" (with an indicator pointing in the direction). "The Custer Battle-Field Nat'l Cem'y."

The southern boundary to the Little Big Horn passes over a slope draining into

Benteen's Creek. This slope is frequently scored by ravines, in one of which, at 3,900 feet from southeast corner, is a spring of alkali water.

The high bank of the river was reached at 8,378 feet from the southeast corner, and the river intersected three times by the boundary line, which continues over the rich bottom on the west side of the river to a point 3 miles from the southeast corner, where a post was established and marked "U. S. N. C., SW. Cor., 1879. The Custer Battle-Field Nat'l Cem'y." This post is set up near the bank of a creek flowing into the Little Big Horn from the west, and on a bench near the level of the table-land above. The southern boundary intersects the McKinney road at 11,348 feet, and the high-water road at 15,000 feet, or within 840 feet of the southwest corner. From this corner the western boundary ascends to the table-land above, and over a remarkably level and luxuriantly-grassed country, intersected by numerous ravines and creek-beds, to the northwest corner, which is situated in a ravine in view from the stage-road, which is only half a mile distant.

A beautiful spring of excellent water was crossed on this line at a distance of 5,880 feet from the southwest corner. The valley of the creek, intersecting at 12,110 feet, is thinly timbered with cottonwood, as are also those crossing at 19,080 and 25,800 feet, respectively.

The northern boundary to the I. P. reaches the left bank of the river at 3,273 feet from the northwestern corner, and crosses three times, reaching the right bank at the third crossing, 4,602 feet from the northwest corner, thence through the timber on the east side of the river and across the bottom to the ridge, and to the place of beginning.

The description of the inclosed 18 square miles may be summed up in a few words: Rich, fertile land with well-grassed hills and meadow valleys; the creeks generally dotted with cottonwood trees, while the river itself is thickly timbered the whole way along its tortuous course. The river affords excellent water. Its average width is 120 feet, and depth at this season 14 inches. The highest elevation on the reserve is a sharp hogback and two buttes situated about 7,500 feet northwest of Reno's position, and forms a part of a regular nest of hills bounded by the river on the west and Reno's Creek on the north. The face of the bluffs toward the river is steep and well washed, while the approaches to Reno's Creek are sloping and well grassed. At that point where the river recedes farthest from the hills and approaches nearest the stage-road, the left bank of the river is perpendicular and 20 feet deep. This portion of the valley is the most elevated, as a glance at the map of the reservation will show. The drainage of the low hills on the west side of the river flows along their base, and enters the river by a deep watercourse near the upper end of the reserve, and renders a bridge necessary at the stage-road crossing. Running water at the crossing.

From Custer Monument, which stands on the highest elevation of the ridge, the ground towards the river rolls and slopes to the bank, which is from 6 to 12 feet in height.

The southern boundary of the proposed military reservation intersects the northern boundary of the proposed national cemetery at a point 6,900 feet from the northeast corner, and again at 4,850 feet the eastern boundary of the national cemetery is crossed, thus inclosing 384¼ acres, or ⅗ of a square mile, in both reservations.

Returning to Fort Custer the Little Big Horn River was meandered to its junction with the Big Horn River, and the work incorporated on the map of the proposed military reservation. The company and post gardens, also Dana's garden, on the left bank of the Little Big Horn River, give ample proof of the fertility of the valley of that river.

LIMESTONE RESERVATION AT FORT C. F. SMITH, MONTANA.

The road to Fort Smith from Fort. Custer on the east side of the Big Horn River leads over the high ground south of the post to the northern extremity of the bad lands over which the southern boundary of the proposed military reserve passes. Here it descends to the valley by means of a good but very winding, and, in some places, steep road. Thence to Fort Smith this valley is followed over good meadow land and rich pasturage, crossing Rotten Grass, Soap, and Plum Creeks before the old post is reached. Camp was pitched near Beaver Dam, on a beautiful mountain stream of excellent water, the principal stream of the valley. This point was reached September 9.

The survey of this reserve was to be governed by the following order:

[General Order No. 2.]

HEADQUARTERS BIG HORN POST, *July 4*, 1877.

Pursuant to instructions from department headquarters, 2 miles square is hereby announced as a government reservation at old Fort Smith, Mont.

Said reservation is hereby located so as to include the old government post, grave-

yard, and the ridge containing the limestone ledge of rock on the east and right bank of the Big Horn River.

By order of Lieutenant-Colonel Buell.

HARRY TIFFANY,
Second Lieutenant, Eleventh Infantry, Post Adjutant.

The directions in the foregoing order seemed so full and explicit that the chief engineer of the department did not consider any further instructions necessary. A preliminary survey, however, developed the fact that these instructions could not be carried out to the letter. The variation of the needle at Fort Smith is 18° 15′ 30″ E. The following boundaries were decided upon and laid out by me, being governed by every consideration contained in the order, with the exception of the exact shape of the reserve.

The place of beginning is a point on the right bank of the Big Horn River, 1,772 feet due north of a point 700 feet due east of the site of the flag-staff of the old post, said site being marked by the butt of the flag-staff, which had been cut away some time previously.

The place of beginning is marked by a cottonwood post 7 feet long, stripped and sunk 3 feet, earth piled to a height of 1 foot; the post marked by mistake "U. S. N. C., 1879, NE. Cor." The letters "U. S. N. C." appear on all the corners, owing to an erroneous impression on my part that the reserve was to be set apart as a national cemetery.

This stake is situated 74 feet due south of high-water mark. Beginning at this stake, the reserve boundary runs due south 1 mile and 5,206 feet; thence due west 2 miles; thence due north to midstream Big Horn River; thence down said midstream to its intersection with the prolongation of the eastern boundary, and thence along said prolongation to the place of beginning.

The eastern boundary runs over a level, well-grassed plain to the base of a sharp sandstone ridge. The southeast corner is situated near the base of this ridge, and 698 feet south of the summit of a small knoll over which the boundary passes, and 2,150 feet south of its intersection with the road to old Fort Phil. Kearney. This corner is marked by a cottonwood stake 7 feet long, stripped and sunk 3 feet, earth piled a height of 1 foot, and inscribed "U. S. N. C., 1879, SE. Cor."

From this corner the southern boundary crosses the sandstone ridge—the main creek—a low, red sandstone ridge, two branches of the main creek, and an accommodation road to the Black Cañon, reaching the base of the Limsetone Ridge at 4,800 feet from the southeast corner. The continuation of the southern boundary crosses a narrow, rocky, precipitous gulch to the edge of a deep, precipitous cañon at 6,274 feet. The edges of this cañon are topped with immense bowlders of limestone rock, which are easily displaced and hurled to the watercourses below.

The line crosses this cañon obliquely, and the western edge is reached at 8,600 feet. Sweet, cool running water passes down the cañon to the creek below. From the western edge of the cañon the remaining 1,960 feet of the line passes over a gradually-sloping and rolling table-land to the southwest corner, where a conical mound of rock 4 feet high was built and marked "U. S. N. C., 1879, S.W. corner." Two solitary pine trees stand on this table-land near the eastern slope of the limestone ridge, by the aid of which the southwest corner may be easily found, as the Beaver Dam, pine trees, and southwest corner are very nearly on line.

The western boundary reaches the eastern slope of Limestone Ridge at 3,800 feet, and passes obliquely down this slope to the mound, indicating the northwest corner of the reserve. This mound is situated 36 feet south of high-water mark, and is built of rock piled up 4 feet, and marked "U. S. N. C., 1879, N.S.W. Cor."

These boundaries include nearly all the available limestone in this section, the quantity of which seems to be inexhaustible. A small amount of limestone lies outside of the reserve on the eastern edge of the cañon before alluded to, which if displaced would roll inside the reserve. Limestone ledges crop out along all the gulches on the ridge. The western boundary encounters some timber on the summit of the ridge, and further down thick brush covers the slope to the river bank. The details from Fort Custer for lime burning as yet confine their search for stone to the loose bowlders, which are thickly strewn all around the reserve in the valley below.

Innumerable beautiful springs and mountain rivulets, with cool, excellent water, exist here, and grapes, wild plums, and bullberries are to be found in profusion. The sandstone ridges to the east of the limestone ridge stand out very prominently, sloping from the east to their summit of sandstone rock, and falling off precipitously to the west.

The cemetery is situated on an elevation near the river, and everything connected with it seems to be in tolerably good condition. The monument erected by Companies D, E, G, H, and I, Twenty-seventh Infantry, June, 1868, to the memory of Lieut. Sigismund Sternberg and others buried there, stands out very conspicuously among its surroundings, being 12 feet in height, and composed as follows: A stone base 3.6

by 2.8 feet by .75 foot, on which stands a block of granite 4 feet high by 1.8 by 1.6 feet, whereon the several names of the persons to whose memory it is dedicated, is inscribed. On this stands a smaller base 6 inches in height by 2.3 by 2.2 feet. This is the only portion of the structure damaged. On this base stands the obelisk, 6.75 feet high, 1.45 feet square at its base, 8 inches square within 4 inches of the summit, and 4 inches square at its summit. The inclosure is 113.6 feet long on its eastern side and 55 feet in width facing the river, built up of partly dressed loose rock to a height of 3½ feet, and 2 feet in thickness. The entrance is 10 feet from the southeast corner of the inclosure on the 55-foot side.

The old post stands on an elevation about 9 feet high, looking from the river bank, from which it is distant about 1,200 feet. The adobe walls of the officers' quarters and barracks, still standing, lend to the situation an appearance of antiquity it would not otherwise possess.

The result of a survey of the site of the old post was incorporated on the map of the reservation.

The location of the flag-staff is 52 feet in front of the commanding officer's quarters. Nothing now remains of it but the stump.

Game is abundant in the vicinity, and not a few bears have been encountered by lime-parties while on duty in this reserve. Rattlesnakes are also plentiful.

The party reached Fort Custer September 14 and Fort Keogh September 22, when the duty ordered by the chief engineer of the department in letter dated "Steamer Butte, August 26, 1879," was completed and the results furnished the commanding officer of the post in obedience to telegraphic instructions from the department commander.

Reached Fort Buford October 22 and arrived in Saint Paul October 29.

I am, sir, very respectfully, your obedient servant,

JAMES E. WILSON,
Topographical Assistant.

The CHIEF ENGINEER,
Department of Dakota, Saint Paul, Minn.

DETERMINATION OF THE ALTITUDE OF FORT CUSTER, MONTANA.

Aneroid barometer No. 1552, *thermometer (mercurial).*

Lower station, Saint Paul, Minn., U. S. signal office:
Barometer, 29.000 inches; thermometer, 72°.5; elevation, 795.5 feet.
Upper station, Fort Custer, Montana:
Barometer (mean of 118 observations), 26.622; thermometer, 75°.6.

Argument $H=26.622$	25,675.9
Argument $h=29.000$	27,921.6
	2,245.7
First approx. difference $\left\{\begin{array}{l} t\ \ = 75.6 \\ t' = 72.5 \\ \hline t+t' = 148.1 \end{array}\right\}$ $2245.7 \times .0933 =$	209.5
	2,455.2
Altitude of lower station	795.5
Altitude of barometer at Custer	3,250.7
Altitude of barometer above center stone parade-ground	12.94
Altitude of center stone parade-ground	3,237.76

From barometer station levels were taken to the Big Horn River near the present ferry.

Center parade-ground above low-water, July 3, 1879	148,389
Center parade-ground below barometer station	12,940
Barometer station below ground base wind-power	7,610
Elevation center stone parade-ground, Fort Custer ... feet	3,237.76
Elevation ground base wind-power ... do	3,258.31
Elevation low-water July 3, 1879, near ferry ... do	3,089.37

SUMMARY OF OBSERVATIONS FOR LATITUDE.

1	45° 43′ 57″.73
2	44° 43′ 57″.34
3	45° 43′ 57″.00
4	45° 43′ 49″.92
5	45° 43′ 48″.98
6	45° 43′ 44″.14
7	45° 43′ 43″.55
8	45° 43′ 41″.69
9	45° 43′ 39″.96
10	45° 43′ 35″.12
11	45° 43′ 28″.61
Mean	45° 43′ 45″.82

OBSERVATIONS FOR MERIDIAN, FORT CUSTER, MONTANA, BY OBSERVING POLARIS AT ITS GREATEST EASTERN ELONGATION.

June 27, 1879.

Star	27° 16′ 10″	
Mag. mer	43 48 50	
		16° 32′ 40″
Star	121 13 40	
Mag. mer	137 46 30	
		16 32 50

June 28, 1879.

Star	150 04 30	
Mag. mer	166 34 00	
		16 29 30
Star	91 59 00	
Mag. mer	75 26 30	
		16 32 30

July 12, 1879.

Star	17 27 30	
Mag. mer	34 04 00	
		16 36 30
Star	161 17 00	
Mag. mer	177 49 00	
		16 32 00

Mean	16 32 40 E.
Star az	1 54 50 E.
Mag. variation	18 27 30 E.

ODOMETER DISTANCES FROM CUSTER TO KEOGH, 1879.

	Local miles.	Total miles.
Left bank Big Horn River, opposite Custer (ferry):		
Mail Ranch, Big Horn River	17.15	17.15
Big Horn Depot (Terry's Landing)	13.75	30.90
Junction City	1.28	32.18
Sherman City (Etchetah, or Guy's Landing)	8.08	40.26
Dry Creek	5.32	45.58
Adjacent Creek (runs adjacent to stage road)	4.04	49.62
Eastern extremity Pease Bottom, Dry Creek	.96	50.58
First Massé Creek	2.48	53.06
Second Massé Creek	4.56	57.62
Froze to Death Creek	1.74	59.36
Mail Ranch	2.30	61 66
Crooked Creek	3.84	65.50
Big Porcupine Creek	13.66	79.16
Cold Spring Ranch	5.16	84.32
Western entrance to cañon, Dry Creek	.53	84.85
Eastern entrance to cañon, Dry Creek	2.97	87.82
Little Porcupine Creek	4.43	92.25
Dry Creek	1.73	93.98
Rosebud Telegraph Station	2.36	96.34
Whisky Ranch	5.81	102.15
Dry Creek	.14	102.29
Small Dry Creek	3.32	105.61
Toll Ranch (Kennedy)	1.84	107.45
End of toll road	1.00	108.45
Creek and end of rough road	3.09	111.54
Dry Creek, Yellowstone River	1.56	113.10
Dry Creek	3.03	116.13
Dry Creek, Yellowstone River	3.66	119.79
Upper Ferry	5.23	125.02
Fort Keogh	2.53	127.55

STAGE-LINE DISTANCE-TABLE FROM BOZEMAN TO TONGUE RIVER.

	Local miles.	Total miles.
Bozeman	16	337
Hopper's	14	321
Benson's Landing	3	307
Shields River	13	304
Hunter's Springs	4	291
Gage's	17	287
Big Timber Creek	10	270
Sweet Grass Creek	25	260
Stillwater Creek	20	235
Young's Point	19	215
Canyon Station	12	196
Coulson	10	184
Huntley	36	174
Pompey's Pillar	14	138
Buffalo Station	19	124
Terry's Landing	7	105
Etchetah (Fort Custer Junction)	22	98
Froze to Death	18	76
Big Porcupine	4	58
Rock Springs	14	54
Little Porcupine	5	40
Johnson's	6	35
Sand Creek	9	29
Bull Creek	20	20
Tongue River	0	0

APPENDIX T T.

EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE PACIFIC.

REPORT OF CAPTAIN WILLIAM A. JONES, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

ENGINEER OFFICE,
HEADQUARTERS MILITARY DIVISION OF THE PACIFIC,
DEPARTMENT OF CALIFORNIA,
Presidio of San Francisco, Cal., July 26, 1880.

SIR: I have the honor to submit the following report of engineer operations in the Department of California for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

W. A. JONES,
Captain of Engineers.

REPORT.

The office was under the charge of First Lieut. Carl F. Palfrey, Corps of Engineers, until October 31, 1879, on which date I relieved him, in compliance with paragraph 5, Special Orders No. 58, Headquarters of the Army, Adjutant-General's Office, dated March 11, 1879, and General Orders No. 11, paragraph 3, Headquarters Military Division of the Pacific and Department of California, dated Presidio of San Francisco, Cal., October 31, 1879.

The office force then consisted of two privates of the general service United States Army, employed as topographical assistants—Mr. Hercules H. Price, and Mr. Julius Fischer. Mr. Fischer was discharged at his own request, February 29, 1880.

Mr. Clement Winstanley was enlisted in the general-service detachment, for service as topographical assistant, on February 14, 1880, and Mr. Thomas H. Humphreys was enlisted for the same purpose on April 5, 1880.

During the winter months the building occupied as office was extensively repaired, and is now commodious and well suited to our work. In the mean time operations were of necessity limited, owing to a lack of proper accommodation.

The operations of the office have been directed to the following purposes:

The survey of military posts and reservations.

Surveys for public buildings and works for water supply at military posts.

The collection of geographical information concerning the region occupied by the troops of the command.

The cartographic work connected with the foregoing.

The duplication of maps by photography.

The distribution of maps and geographical information among the officers of the command.

The following military reconnaissances (scouts) have been made by the troops in the field:

No.	From—	To—	By whom made.	No. of miles traveled
1	Fort Bidwell, Cal ...	Southwest of post, past Alturas, to Warm Spring Valley, Alkali Flat, and return, via Fandango Valley.	Capt. Henry Wagner, First U. S. Cavalry.	127.4
2	Fort Halleck, Nev....	Duck Valley Indian Reservation, and return.	Capt. C. C. C. Carr, First U. S. Cavalry.	206.00
3	Fort McDermit, Nev...	Catlow's Ranch and return .	Lieut. J. A. Hutton, Eighth U. S. Infantry.	146.00
4	Fort Gaston, Cal......	Stone Lagoon and return ...	Capt. E. B. Savage, Eighth U. S. Infantry.	39.50
5	Fort McDermit, Nev..	Martin Creek and return ...	Lieut. J. A. Hutton, Eighth U. S. Infantry.	123.00
6	......do	Disaster Peak and return....	Lieut. J. H. Hutton, Eighth U. S. Infantry.	83.00
7	......do	Quinn's River Mountains, McDermit Cañon, and return.	Lieut. J. H. Hutton, Eighth U. S. Infantry.	256.00
8	......do	Western Shoshone Indian Reservation, Nev., and return.	Lieut. R. Parker, Eighth U. S. Infantry.	164.00
9	Fort Halleck, Nev ..	Upper ferries of the Snake River, Ind. T., and return.	Lieut. P. H. Ray, Eighth U. S. Infantry.	445.00
			Total	1 589.90

The information obtained on these has been embodied in service maps, which have been duplicated by photography.

Located and graded road between Presidio and Fort Point.

Road from Presidio to First Avenue laid out.

Road around Presidio laid out.

Surveyed road to Fort Point.

Survey made of Post of Presidio.

Ranges for target-practice at Presidio established.

Line of levels run between dam and service-reservoir at Fort Point.

Survey made for locating two water-tanks on Presidio Reservation.

Water-supply of Benicia—examination and report.

Water-supply of Presidio—examination and report.

Maps of all the posts and reservations in the Department of California have been prepared on a special scale for the office files at headquarters of the Army, as follows:

Angel Island, Alcatraz, Benicia Barracks and Arsenal.

Fort Bidwell, Camp Independence (unoccupied), Fort Gaston, Fort Halleck, Fort McDermit, Fort and Reservation at Monterey, Fort Point, Fort Point San José, Presidio of San Francisco, San Diego Barracks, and Yerba Buena Island.

Also maps of the following:

Camp Rucker, Arizona; Camp Huachuca, Arizona; Camp Howard, Idaho; Cœur d' Aléne Reservation, Idaho; and 2 copies Cœur d' Aléne Post, Idaho; and 2 copies Benicia Reservation, California (copy); San Diego Barracks, California; Oregon (part of), copy; Alcatraz Island, California; Camp Independence, California; Monterey, California; Presidio (post of), 11 copies; Fort Townsend, 2 copies; Fort Colville, 2 copies; Walla-Walla Meadow Reserve (copy); Point San José, California (copy); Alcatraz Island (copy); Monterey (copy); Benicia (copy).

Architectural drawings have been prepared as follows:

School-house at Presidio of San Francisco, Cal. (plans and working drawings).

Plans officers' quarters, Fort Point, California.

Plan of buildings at Fort Point (2 copies).

Plans of company quarters Fort Point, California (copy).
Plans of new buildings at Alcatraz Island, California (copy).
Plan of officers' quarters, Presidio of San Francisco, California (copy).
Sketch aiming-stand and tripod (copy).
Diagram of horse-taming, sketches; 1940 copies of maps, plans, and sketches have been produced by photography and distributed.
One set battle-field maps, mounted.
Three copies map of Great Plain, Columbia River, mounted.
One map United States, mounted.
Three maps Western Territories, mounted.
It is proposed during the year ending June 30, 1881, to make a reconnaissance in person of the region lying north of the Central Pacific Railroad in Nevada, with the view of opening lines of communication between points on that railroad and the Great Basin of Snake River. Also to continue the usual operations of the office.

ESTIMATE.

Amount expended in fiscal year ending June 30, 1880	$303 15
Amount to be expended during fiscal year ending June 30, 1881	1,500 00
Amount required for fiscal year ending June 30, 1882	10,000 00

The CHIEF OF ENGINEERS UNITED STATES ARMY,
Washington, D. C.,
(Through Headquarters Military Division Pacific and Department of California.)

APPENDIX U U.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF ARIZONA.

REPORT OF LIEUTENANT CARL F. PALFREY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF ARIZONA,
Whipple Barracks, Prescott, Ariz., July 1, 1880.

SIR: I have the honor to submit the following report of this office for part of the fiscal year ending June 30, 1880, during which it has been under my charge.

PERSONNEL.

Pursuant to General Orders No. 20, Headquarters Department of Arizona, dated November 25, 1879, I assumed charge of this office December 1, 1879, relieving First Lieut. F. A. Smith, adjutant Twelfth Infantry.

Two topographical assistants, enlisted in the general service, United States Army, were employed until February 29, 1880; since that date, one.

Since June 1 a private of the Twelfth Infantry has been on daily duty in this office with a view to his transfer to the general service if proved competent to the duty of topographical assistant.

FIELD WORK.

1. By direction of the commanding general, Division of the Pacific, an examination was made of the ground near the junction of the Verde and Salt Rivers, with a view to the irrigation of the reservation north of the Salt River for the Pima and Maricopa Indians, by water of the Verde River. After barometric reconnaissance of two lines, a line of levels of about nine miles was run with 16-inch spirit-level, horizontal angles and stadia distances being taken with a somewhat rough instrument borrowed from the Quartermaster's Department.

In this work I had with me one of the topographical assistants. Transportation and other assistance was furnished from the neighboring garrison of Fort McDowell.

2. A survey preliminary to application for declaratory order was made of the boundaries of a proposed military reservation at Camp Huachuca. Lines in open country, about 18 miles, were chained; those in the mountain defined by natural landmarks, and not measured.

I had here the assistance of an enlisted man from the garrison, the only topographical assistant being required for office work.

3. A like survey has been made of proposed reservation at Camp John A. Rucker. In this mountain gorge trustworthy chaining of long lines could hardly have been made by experienced chainmen. The principal points of the adjacent ground were therefore located by triangulation from a short base, and measurements taken on the plat. Such assistance as could be rendered in this work was furnished from the garrison.

In the lack of funds to cover incidental expenses, no field work for topographical information alone has been attempted. While traveling on duty, 1,062 miles, I have taken such notes as the mode of conveyance

permitted, for the correction of the published maps. Topographical Assistant Rucker, on furlough during June, has kept notes of about 500 miles of travel.

The instrumental equipment for field work is meager, and not adapted in many particulars to the kind of work required. It is hoped that the invoice of instruments now on the way from the engineer depot will, in great measure, supply deficiencies.

OFFICE WORK.

1. *Maps and plans of posts.*—Road maps on a scale of 1 inch to 6 miles have been copied from the "Map of Western Territories," on tracing-linen, for photographic printing. Three sheets (lat. 31°–34°; long. 108°–112°; lat. 33° 30′–36°; long. 109°–113°; lat. 33° 30′–36° 30′; long. 111° 30′–115°) give the regions most important in military operations in and from this department. A few copies from the first sheet have been printed at division headquarters, and now await mounting for distribution to posts.

Sheets of Northern Mexico have been prepared, but not forwarded for printing.

Plans of Forts Verde, Whipple, and McDowell have been prepared in accordance with requirements from Headquarters of the Army.

2. *Plans of buildings and other drawings.*—Tracings have been made for the Quartermaster's Department from working-drawings of buildings at posts in this department—11 sheets.

Drawings have been made to accompany specifications of certain improvements in ordnance sent from these headquarters—4 sheets.

3. *Map-mounting.*—Twenty-four single-sheet maps have been mounted. The mounting of large maps has been impossible from the narrow space allotted to this office—one small room for draughting, map-mounting, and storage of instruments, maps, and materials. I have just secured the temporary use of another room, which will enable me, while I retain it, to issue maps in form fit for office and traveling use.

Maps received since December 1.—From Lieut. F. Von Schrader, Twelfth Infantry, one map of Truto Basin, compiled from various published authorities, with additions from personal observation (not instrumental).

From Lieut. Guy Howard, Twelfth Infantry, field-book of a scout with Company D, Indian scouts, from Camp Thomas, Ariz., to Fort Bayard, N. Mex., and return.

It is hoped that the road maps above reported may bring into this office, in the form of corrections and additions, topographical information which officers unaccustomed to drawing have not hitherto reported on account of the difficulty of preparing independent maps.

Maps issued since December 1, 1871.—It would be very desirable, if appropriations admit, that this office be enabled to do its own photographic printing. Neither the appliances nor the materials for the process by prussiate of potash are expensive, while the delays of mail transit between here and San Francisco (five days each way) are inconvenient and may be at times important. The facility of keeping negatives corrected by latest information, printing small supplies as called for, would render the maps more serviceable.

I have the honor to be, very respectfully, your obedient servant,

CARL F. PALFREY,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS,
United States Army.

APPENDIX V V.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLUMBIA.

REPORT OF LIEUTENANT THOMAS W. SYMONS, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

HEADQUARTERS DEPARTMENT OF THE COLUMBIA,
OFFICE OF THE CHIEF ENGINEER,
Vancouver Barracks, Wash., July 7, 1880.

GENERAL: I have the honor to make the following report, as chief engineer of the Department of the Columbia, for the fiscal year ending June 30, 1880. In obedience to Special Orders No. 58, paragraph 5, Adjutant-General's Office, 1879, I was relieved from duty with the geographical survey west of the 100th meridian, and I reported on the 15th of July to General O. O. Howard, commanding this department, and was assigned by General Orders No. 10 as chief engineer of the Department of the Columbia.

Upon taking possession of the office I found everything in a state of chaos, all the records in a mixed, promiscuous mass, with no drawing-boards, tables, or furniture necessary for the official work required. Through the kindly assistance of the Quartermaster's Department in furnishing tables, book and map cases, &c., I have had the office put in proper order, all the maps, plots, drawings, books, &c., classified, numbered, and arranged systematically.

I have arranged and projected a map of the department on a scale of 8 miles to 1 inch, said map being comprised in four sheets, three of which have had considerable work done on them in the way of compilation of the information gained from surveys in the field, from the records of the office, from information furnished by officers and others, and from the reconnaissances of various officers, particularly Lieutenant-Colonel Merriam, Second Infantry, Captain Winters, First Cavalry, Lieutenant Rowell, Second Infantry, W. C. Brown, First Cavalry, and E. K. Webster, Second Infantry.

Another sheet has been projected on a scale of 16 miles to 1 inch, comprising the whole department, and upon which a great deal of work has been done by Topographical Assistant A. Downing, general service. This map I design having published as soon as completed. I have had in view to put upon it everything that could be known with any degree of accuracy, and which would be of use to officers and soldiers, to travelers, emigrants, and others coming into the country, and at the same time to make it as simple and easily understood as possible; and as it is not possible at the present time to give all the detailed mountain topography correctly, I have on this map confined myself to indicating this topography in only a general way, without much attempt at detail. It is hoped that this map will be ready for publication next winter, when the results of this summer's surveys will be incorporated in it.

Through the assistance of the Quartermaster's Department, I have arranged and fitted up a photographic room for reproducing maps by the Blue process, and a number, about 60, of the maps of the Great

Plain of the Columbia have been printed and circulated to officers and others. Also by this process have been printed various other maps. plots, and drawings for the use of the different departments of the Army.

On the 10th of August I left Vancouver for Fort Walla Walla, and served as a member of a board to investigate and report upon the (then) present supply of water at the post and the means of obtaining a greater supply of good water. The board made its recommendations, which have since been carried into effect, and Fort Walla Walla now has an abundant supply of pure and wholesome water. The water is obtained from Singleton's Spring, and is conveyed to the post in iron pipes, the distance being about 1½ miles.

It having been decided to establish a new post somewhere along the great northwestern bend of the Columbia in the vicinity of the mouth of the Okanagan, my next duties were in reference to the selection of the site for the new post and locating the best routes of communication thereto. In furtherance of this scheme, a temporary camp had been established near the mouth of the Okanagan, and supplies were being sent by wagon from Walla Walla. I sent Mr. Manning, one of my assistants, to survey and report upon the route pursued by the wagon-train. This he did, and found the road to be 212 miles long, and that it passed over a country partly composed of sandy sage brush, hills, and drifts, but mostly rolling bunch-grass hills and hollows, with here and there a little rocky-sided coulée, in which generally were found springs. The greatest difficulty on the road was experienced in crossing the Grand Coulée, which was crossed at its junction with the Columbia. This difficulty could have been largely avoided and the road shortened by crossing the Coulée where we entered it, about 30 miles from its junction with the Columbia.

I left Walla Walla myself with my assistant, P. J. Wittman, and three soldiers detailed from Company H, First Cavalry, Corporal Bennett and Privates Ryan and Miller, and a small pack-train, and proceeded to Wallula and thence up the Columbia to White Bluffs, at the head of the long island. At this point, the head of the long island, we left the river to look out for a practicable route for a wagon-road to the camp on the Okanagan, on the supposition that it was to be permanently located there.

We reached the top of the bluffs, which are here about 540 feet high, by going up through a long gulch greatly beaten up by cattle. The soil is dry and is ground to powder by the feet of cattle wherever they make a path, and is not well suited for a road. We, however, found, a short distance down the river, a gulch up which ascent to the top of the bluffs would be comparatively easy and good for wagons. On the top of the bluffs the country spread out gently rolling as far as the eye could reach to the northeast and east. To the north and northwest a small mountain chain devoid of timber stretched itself from east to west across our way. It is called Saddle Mountain. The country was covered with a luxuriant growth of bunch-grass, with here and there a tract of sage brush, the soil of firm and excellent quality. Quite a large number of cattle were seen, all of which had to descend to the river for water.

Proceeding somewhat to the northeast to skirt Saddle Mountain, we soon found ourselves getting into a country more sandy and more rolling, and our mules and horses had greater difficulty in getting along. In the afternoon, being on the lookout for water, we made for a green-looking spot off to the east, hoping it was a spring. In this we were disappointed, and we continued on our way until nine o'clock at night when, not finding any water, we unloaded and made ourselves as com-

fortable as possible without water. The next morning before daybreak we took up our laborsome march through the sands of the desert and traveled on this course until about two in the afternoon, when, as our animals were suffering intensely from thirst, and as we were uncertain about what lay before us directly north, we concluded to strike to the westward, as from all the indications it was more likely to give us a supply of water. About three o'clock we came to a road which gave indications of having at one time been well traveled, and we turned and followed it trusting that it would take us to water. At five o'clock our animals seemed utterly unable to carry their packs any further and so we unloaded them and piled up our baggage and kept on. About nine o'clock that night we came to a small alkali pond, which, vile as it was, seemed like nectar to us and to our poor horses and mules.

The country we had traveled was covered partly with sage brush and partly with bunch-grass, rolling and utterly waterless and lifeless. Not even the cheerful coyote lived there, for not one lulled us to sleep or touched our abandoned provisions and camp equipage. The next day we found the fine spring which feeds the alkali pond above mentioned. I afterwards learned that it goes by the name of Black Rock Spring. Here the face of the country changes to a certain extent and becomes more broken up and merges into the coulée country. Black Rock Spring is at the head of a coulée which extends off to the southwest, and probably as far as Moses Lake.

Near Black Rock Spring the road we had been traveling forked, going northeast toward the Spokan country and north to Crab Creek, which direction we followed and in about 9 miles came to Crab Creek, which is here quite a stream, flowing through a rich bottom about a half mile wide. Up the stream the bottom narrows and becomes a chasm formed by the perpendicular and overhanging walls of basaltic rock. Lower down the bottom became a marsh, entirely filling the space between the coulée walls, and in which the creek sinks to collect again further below. Where we crossed it, the bottom was good and the descent and ascent from the great table-land were comparatively easy. A goodly number of fine fat cattle inhabited this valley and the adjoining high grounds, and no doubt fine gardens could be made and nearly every garden vegetable raised.

Leaving Crab Creek we went nearly northward, taking as a guide the Pilot Rock, a mass of rock about 30 feet high, but which, on account of the general flatness of the country, can be seen for a great distance in every direction. Soon we crossed Kenewaw Run, the dry bed of a winter stream, now containing a scanty supply of water in lakes and springs.

Leaving this we crossed shortly afterwards Wilson Creek, a fine little stream flowing through a rich bottom. It and Kenewaw Run are deeply imbedded below the general surface of the Great Plain of the Columbia, have fine soil and abundant grazing in the bottom and the adjacent hills and upper plains for great numbers of cattle or horses. The scarcity of timber of any kind for fuel and building purposes is, and must always be, a great drawback to the settlement of this section and comfortable living there. There seems little chance of ever finding any coal in the vicinity, and the only hope is to plant trees for fuel and procure lumber from the Spokan and Columbia Rivers. Keeping on over the part of the Great Plain lying between Wilson Creek and the Grand Coulée, a rich rolling country covered with a luxuriant growth of bunch-grass, we descended by mistake into the wrong coulée, which has received the name of Monumental Coulée, from the great bowlders and small table-rocks which abound in it. Down through this coulée,

which heads here, runs the great trail of the Indians from the Spokan country to the Wenatchee and Moses Lake countries. We climbed out of this coulée, and, passing over the broken and rocky summit between the two coulées, we descended by a long gradual slope of about three miles into the Grand Coulée.

The Pilot Rock was right above us on the western bank; a little to the south the banks broke away and formed a gentle slope from the coulée bottom up to the Great Plain to the west. Further south in the coulée the bottom became rocky, and springs apparently abounded, with bunch-grass in great abundance. Here, then, in this vicinity is the best place to cross the coulée for a road going east and west. Right here seems to be the general center of the coulée system. They nearly all seem to head in this vicinity and to radiate off. I cannot conceive of these coulées being anything else than great lava cracks. The whole plain of the Columbia was once a lake of molten rock, which on cooling and contracting, cracked and formed the germs of these coulées. The gradual upheaval of the whole northern country, of which there is no doubt, has widened them, and the storms and frosts have leveled off their bottoms and cracked down their sides a little. That this is the history of their formation may, I think, be proven by the Steamboat Rock, a table of rock which lies in an enlargement of the Great Coulée. Its top is level with the sides of the coulée and identical with them in material and form, and its bulk corresponds with the enlargement of the coulée. It is utterly impossible that they could ever have been the old beds of the Columbia. The bottoms are uneven and a thousand feet above the present level of the river; the sides show no water-marks, and several of the coulées head near where we crossed. We went north through the coulée, its perpendicular walls forming a vista like some grand old ruined roofless hall, down which we traveled hour after hour. The walls are about 300 to 400 feet high. At about seven miles from the river a trail crosses the coulée, and we turned here and went to the west until we struck Foster Creek, down which we kept, following the wagon road made by the troops which preceded us to the winter camp and which crosses the Coulée at its junction with the Columbia River. Some good ranching land lies along Foster Creek, and all over the northern portion of the Great Plain bunch-grass grows in the greatest luxuriance. There are numerous little ponds which, fed by springs, keep a supply of water all the year, and also numerous springs of excellent water.

At the camp near the mouth of Foster Creek I found my assistant, Mr. Manning, who had made a survey of the road from Walla Walla, pursued by the supply train.

Pursuant to instructions from General Howard, Lieutenant-Colonel Merriam and I began a search for the most suitable location for the new post. We examined both sides of the river from the winter camp, about 5 miles above the mouth of the Okanagan to Lake Chelan, and decided that the most advantageous site, taking everything into consideration, was at the outlet of Lake Chelan, the plateau on the north side of the lake and river. An unlimited supply of timber and the purest water is at hand and available for every purpose. Lake Chelan is a wonderfully beautiful sheet of water, about 60 miles long and from 1 to 5 miles wide. It seems to be and is in fact a dammed-up mountain cañon of the most ragged and pronounced description. The water is of diamond-like clearness and yet in places no sight can penetrate to the bottom of its liquid depths. It is supplied from mountain-springs

and from the melting snows of the mass of snow-capped mountains lying about Mount Baker.

In a dug-out canoe, paddled by old In-na-ma-setch-a, the chief of the Chelans and his two sons, Colonel Merriam and I went up the lake about 24 miles, and found it to increase in rugged grandeur and beauty at every paddle-stroke. Walls of granite rose in places almost vertically for a thousand feet above the waters and down below them farther than eye could reach. Elsewhere the steep mountain-walls were covered with fine pine and fir and dense undergrowth. Game was abundant as evidenced by the game trails and the reports of the Indians. At one of our landings Colonel Merriam killed a black bear and saw two others. We were sorry not to be able to go any farther up the lake. It is the most grandly beautiful lake that I have ever seen. It lies about 250 feet above the Columbia and discharges its waters through a gorge, a cleft-like channel a mile and a half long and only a few feet in width. Colonel Merriam was going shortly afterward to make an examination for a wagon road from Chelan to White Bluffs, and I sent my assistant, Mr. Wittman, to make a survey of the route selected. This route is shown on the map of the Great Plain of the Columbia derived from this survey, and Colonel Merriam's subsequent modifications.

After deciding upon the location of the post, I left the temporary camp to go to the Spokan Falls and Fort Cœur d'Alene. The country traversed was nearly all rolling bunch-grass land of the richest description, and most of which will, I believe, be available for raising grain. Near Spokan Falls the country is settling very fast, and if the tide of emigration continues, as it undoubtedly will, in a few years the production of grain and farm-produce in this vast and new section will be enormous, and with the Northern Pacific Railroad and the Columbia River to furnish an easy and cheap carriage to market, its prosperity is assured to a very bountiful extent. Where so many localities are blessed it is hard to particularize them; perhaps the Four Lakes and Crab Creek Counties are the best sections. The main central commercial point must be Spokan Falls, where already quite a town was built and people were flocking in. This town is located on the south bank of the Spokan River at the falls, which furnish one of the finest water powers in the world. Here I made surveys and examinations for a bridge which the military authorities proposed to build for communicating with Forts Cœur d'Alene and Colville, and sent in estimates therefor. Thence I went to Fort Cœur d'Alene and surveyed out the reservation as declared in General Orders No. 12 (1879), Department of the Columbia. Since then it has been decided that the 640 acres limit in regard to military reservations applies to Idaho, and consequently the reservation has to be abandoned. I then laid out on the map constructed at this office a post, wood, hay, and winter pasture reservation, each of 640 acres, which have not as yet been surveyed. Leaving Cœur d'Alene, I returned to Vancouver via Walla Walla, reaching headquarters October 31, 1879.

I have commenced the compilation of a table of distances for the department, but have not as yet finished it.

I shall start in a few days to make a survey for a wagon road from Camp Chelan to the nearest and most convenient point on the Northern Pacific Railroad. I expect this point will be in the vicinity of the Big or Colville Lake. This will enable me to make a more thorough study of the region embraced in the Coulée country, of which no correct knowledge in its entirety has ever been obtained. Capt. Charles Bendire, First Cavalry, has been ordered out on a scout which will take nearly all the

summer, and Assistant Topographer Manning has been ordered to accompany and assist Lieut. W. C. Brown, of the First Cavalry, who goes with the company to make a survey of the country passed over. The scout will be in the Palouse and Spokan countries, and later in the season possibly in the Salmon River country.

It is very much to be regretted that more funds are not at my disposal for the purpose of pursuing the very much needed inquiries, surveys, and reconnaissances in this department. A very great deal of the department is only known in the most general and vague way, and this knowledge is generally confined to a few adventurous men who penetrate into its wild recesses prospecting, or to the officers and men who are compelled to blindly penetrate its depths in pursuit of hostile Indians. A general knowledge of the country can be obtained by consultation with those persons, but they generally are unable or unwilling to take any notes or measurements, and their accounts are colored by the various phases of their minds, and have no degree of accuracy. A small amount of money devoted each year to obtaining a knowledge of these unknown regions would be of very great value to all in the department and in the country, and I would respectfully recommend and request that an appropriation of $5,000 be made for military surveys in the Department of the Columbia.

The following is the statement of the funds which I have received, expended, and have on hand for surveys for military defenses, 1876:

Received	$300 00
Expended July 1, 1880	206 53
On hand July 1, 1880	93 47

I have the honor, also, to submit the following report on the improvement and repair of the military wagon road from Scottsburg to Camp Stewart, Oregon:

IMPROVEMENT OF MILITARY WAGON ROAD FROM SCOTTSBURG TO CAMP STEWART, OREGON.

Agreeably to instructions from the Adjutant-General's Office, I made an examination and report upon the military wagon road from Scottsburg to Camp Stewart with reference to the application of an appropriation of $10,000 made therefor by Congress during the session of 1878–'79. The portion of the road from Scottsburg to Roseburg is no longer used at all by the military and very little by any one. The portion from Roseburg to Camp Stewart is a part of the great overland mail-route from California to Oregon, and over it the supplies for Fort Klamath are hauled. I therefore recommended that the money all be spent on this last-named portion of the road and upon such parts as were the worst and where the people were fewest and least able to repair and keep the road in order, namely, about Cow Creek hill and slough and valley and the other bad places in the vicinity.

These recommendations were approved, and I was assigned to the charge of the work. On the 1st of April I started work on Cow Creek hill, and have now an excellent and well-constructed grade up this hill, which has always been a terror to teamsters and stage-drivers. This grade is a zigzag with eight turns, the turns being wide and ample enough to work ten and twelve horses. It has all been ditched and turnpiked, supplied with culverts, and all soft places covered well with broken stone and gravel. This grade is 2,914 feet in length.

In the valley of Cow Creek a great deal of work has been done in

ditching, turnpiking, putting in culverts and bridging the small branches. The total length of road so made is 3,714 feet. Grave Creek hill has been improved by changing the location of the road in some places and grading, turnpiking, and ditching all the road, and graveling wherever the soil needs it. The total length of road constructed on this hill is 5,148 feet.

When the road was first located through these hills a great mistake was made by putting it on the hillside and over jutting points which all work up into red mud and become almost impassable. The creek and branch-bottoms are in nearly every case better ground, being gravelly and solid. This is the case with the hill between Coyote Creek and Grave Creek on the northern side. This hill, of more than two miles in length, I have improved by locating the road, where practicable, in the creek and branch-bottoms, and constructing a grade up the hill to the first divide, 8,163 feet in length. At the second divide, or main summit of the hill, I have built a zigzag grade up a very steep pitch, 1,556 feet in length.

I have also built a bridge 56 feet long over Coyote Creek. This bridge consists of 4 beams 40 feet long by 14 by 18 inches and covered with hewn saplings 4 inches thick. The approach on one side is of the same character and 16 feet long.

In the valley of Wolf Creek a new road was constructed about 100 to 150 feet west of the old road. The old road ran through bogs most of the way which it was impracticable to drain, and the change in location was made to place it on a rocky hillside which could be easily drained. The length of new road constructed here is 2,673 feet.

I employed and put to work a number of men and teams in the black mud lanes between Roberts Hill and Roseburg, with the view to put a section of this road in good order to serve as model for the further improvement of the whole road. I also employed men to run some ditches through an excessively bad portion of the road near Myrtle Creek. A bridge was built across Grave Creek and its slough. This bridge has a main span of 55 feet, consisting of 4 hewn stringers, each 14 inches thick and 16 inches deep at the ends and 20 inches deep at the center, covered with hewn saplings 4 inches thick, all of red fir. In the bridge across the slough, of 57 feet in length, use was made of the timbers of the old bridge and such new timbers as were necessary.

On these hills, Cow Creek, Coyote Creek, and Grave Creek hills, I have devoted myself to improving the northern side, as the heaviest freight passes south. This portion of the road from Galesville, about 5 miles north of the crossing of Cow Creek, to Jump-off-Joe Creek, a distance of about 20 miles, passes over three high ranges of hills varying from 500 to 900 feet above their creek bottoms, and several smaller hills of from 20 to 200 feet altitude. It is either up or down hill nearly all the way, and in the first building of the road, no provisions having been made for water, it has coursed down the road, following the wagon tracks, until the road has become a vast system of gulleys. Wherever a spring came out, or the water settled, a mud-hole was formed, into which a few pine boughs would be thrown to make it temporarily passable, only to make it worse in the future; heavy freight wagons passing over ground down into mud often up to their axle. The stages carrying the United States mail, each loaded with from 800 to 2,000 pounds of mail, drawn by six horses, often mired down or upset, and in some cases lost the mail. It has been almost an impossibility to get freight to Fort Klamath during nearly six months of the year. I doubt if there existed in the United States a worse road, for the amount of

traffic going over it and the importance of the road, the great thoroughfare between California and Oregon. The people living along the road are not able to build it or keep it in order, as there are very few living in these mountains, and they are comparatively poor.

The appropriation of $10,000 has done a great deal towards permanently improving the road, but it is far from being a good road all the way yet. An additional appropriation of $5,000 would make a good road all the way over these hills, a road which would be easily passable at all seasons of the year; and, on account of the importance of the road and the total lack of any other means for its improvement, I would most respectfully recommend that an additional appropriation of $5,000 be granted to complete the road across these mountains.

There are very many very bad places on the road between Canyonville and Roseburg, especially in those portions which pass over the black mud bottoms of the Umpqua. These roads become exceedingly bad in the winter, working up into thick, sticky, black mud, into which wheels go often to the axletrees. Nearly the whole of this distance should be turnpiked and graveled. Gravel can be procured from the bed of the Umpqua, and a road once made in this manner could be kept in order by the people, who now are unable to make the road in the first place as it should be made.

I would respectfully recommend that the sum of $10,000 be appropriated to put this portion of the road from Roseburg to Canyonville in good condition.

The appropriation of $10,000 has all been expended.

Estimates for complete permanent improvement of the road from Roseburg to Jump-off-Joe Creek, $15,000.

I have the honor to be, sir, very respectfully, your obedient servant,

THOMAS W. SYMONS,
Lieutenant of Engineers,
Chief Engineer Department of the Columbia.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. Army.

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